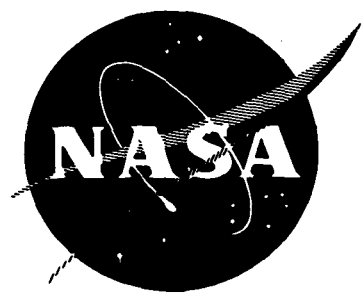
SPECIAL NOTICE INSIDE

Research and Technology Operating Plan



SUMMARY

FISCAL YEAR 1974
RESEARCH AND
TECHNOLOGY PROGRAM

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

This Supplement is available from the National Technical Information Service (NTIS), Springfield, Virginia 22151, for $3.00. For copies mailed to addresses outside the United States, add $2.50 per copy for handling and postage.

SPECIAL NOTICE

Beginning with this issue, a new section has been added to the *RTOP Summary*. The new section lists RTOPs announced in earlier issues which have been changed, completed or terminated. Please refer to Table of Contents for location of the new section entitled "RTOP Change Listing."

INTRODUCTION

This publication represents the NASA Research and Technology program for FY 1974. It is a compilation of the "Summary" portions of each of the RTOPs (Research and Technology Operating Plans) used for management review and control of research currently in progress throughout NASA. The *RTOP Summary* is designed to facilitate communication and coordination among concerned technical personnel in government, in industry, and in universities. We believe also that this publication can help to expedite the technology transfer process.

The *RTOP Summary* is arranged in six sections. The first section contains citations and abstracts of the RTOPs. The second section lists RTOPs announced in earlier issues of the *RTOP Summary* which have been changed, completed or terminated. Following this section are four indexes: Subject, Technical Monitor, Responsible NASA Organization, and RTOP Number.

The Subject Index is an alphabetical listing of the main subject headings by which the RTOPs have been identified.

The Technical Monitor Index is an alphabetical listing of the names of individuals responsible for the RTOP.

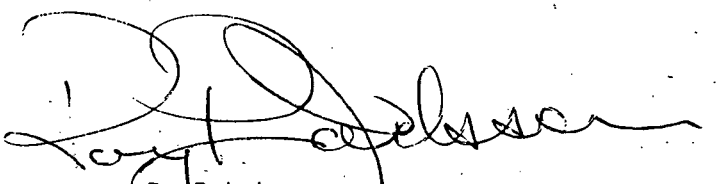
The Responsible NASA Organization Index is an alphabetical listing of the NASA organizations which developed the RTOPs contained in the Journal.

The RTOP Number Index provides a cross-index from the RTOP number assigned by the NASA responsible organization to the corresponding accession number assigned sequentially to the RTOPs in *RTOP Summary*.

As indicated above, responsible technical monitors are listed on the RTOP summaries. Although personal exchanges of a professional nature are encouraged, your consideration is requested in avoiding excessive contacts which might be disruptive to on-going research and development.

Any comments or suggestions you may have to help us evaluate or improve the effectiveness of the *RTOP Summary* would be appreciated. These should be forwarded to:

National Aeronautics and Space Administration
Office of Aeronautics and Space Technology
Resources and Institutional Management Division (RMP)
Washington, D.C. 20546



Roy P. Jackson
Associate Administrator for
Aeronautics and Space Technology

TABLE OF CONTENTS

Page

Office of Aeronautics and Space Technology

AERONAUTICS RESEARCH AND TECHNOLOGY BASE

SPACE RESEARCH AND TECHNOLOGY BASE

SPACE SYSTEMS AND EXPERIMENTAL PROGRAMS

Office of Applications

Office of Space Science

Office of Tracking and Data Acquisition

Office of Manned Space Flight

Indexes

TYPICAL CITATION AND TECHNICAL SUMMARY

RTOP ACCESSION NUMBER → W74-70063 — 501-24-08 ← RTOP CURRENT NUMBER

RESPONSIBLE NASA ORGANIZATION → Lewis Research Center, Cleveland, Ohio.

TITLE → **COMBUSTOR TECHNOLOGY**

TECHNICAL MONITOR → Richard A. Rudey 216-433-6160 ← TELEPHONE NUMBER

RELATED RTOPS → (501-24-02; 501-24-18; 501-24-20)

TECHNICAL SUMMARY →

Primary combustor research will establish the technology necessary for combustors having high performance and good durability at operating conditions typical of advanced commercial and military aircraft. Two different types of combustors are being investigated: a double-annqlar ram-induction combustor and the swirl-can modular combustor. Extensive tests are needed to assess the overall merit of each design. Several varieties of small (less than or equals 10 lbs/sec flow rate) reverse flow and axial flow type combustors will be designed and tested for performance and emission evaluations. A reheat burner program will be aimed primarily at the mixed-flow engine having a high temperature core exhaust stream. A variety of reheat burner concepts will be investigated and will evaluate fuel prevaporization and fuzl-air premixing. Research will also be conducted on liner film-cooling, jet penetration and mixing, modified swirl-can modules, and high Mach number diffuser designs.

RESEARCH AND TECHNOLOGY OPERATING PLAN

a summary

FISCAL YEAR 1974

OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

Aeronautics Research and Technology Base

W74-70001 **501-01-06**
Lewis Research Center, Cleveland, Ohio.
RELATIONSHIP OF ATOMIC STRUCTURES WITH MATERIAL PROPERTIES
J. C. Freche 216-433-4000

The broad objective of this work is to gain a better understanding of the basic structure and behavior of metallic and nonmetallic materials. The ultimate value of such an improved understanding will be in its utilization to produce new and improved materials particularly for aeronautical applications. The approach taken to achieve this improved understanding is to conduct basic research on both model material systems as well as more realistic compositions. Three broad classes of materials are included in the effort; these are alloys, coatings, and refractory compounds. The alloys portion is concerned primarily with dispersion strengthening mechanisms and unique metallic structures as produced by ultra fast cooling (splat cooling) and by slow directional cooling (directionally solidified eutectics). The coatings effort deals with the stability of intermetallic materials, coating-alloy interdiffusion, and oxidation.

W74-70002 **501-21-23**
Lewis Research Center, Cleveland, Ohio.
COMPOSITES
J. C. Freche 216-433-4000

The overall objective of this research is to develop fiber and laminate composite materials, structures, and components for various aeronautical applications. Both polymer and metal matrix composites must exhibit greater strengths, toughness, modulus of elasticity, and wherever possible lighter weight than bulk, monolithic engineering materials. Superior property-to-weight advantages (e.g., specific weight or specific moduli) must be maintained at temperature levels of interest which range from cryogenic temperatures to over 2500 F. The work is oriented toward use of these materials in advanced gas turbine engines and major efforts are geared toward increasing use temperatures for fan blades, compressor blades, turbine buckets, and nozzle vanes, while maintaining superior property-to-weight advantages.

W74-70003 **501-21-23**
Langley Research Center, Langley Station, Va.
COMPOSITES
George W. Brooks 703-827-2042
(501-22-03; 766-74-01)

The objective is to define and investigate superior reinforcements and matrix materials for filamentary composites and to study the fundamental mechanical and chemical behavior of structural composites. The work will focus on investigation of new or advanced filamentary materials, matrix materials and composites to establish mechanical properties, fabrication problems, and resistance to appropriate environments with a view toward their structural applications in advanced aeronautical vehicles. Laminates with controlled flaws and disbonds will be used in developing holographic techniques for nondestructive evaluation. Resin matrix development will emphasize systems that combine good thermo-oxidative stability and mild processing conditions. Studies will also be made of adhesives, resins, bonding of resin-matrix composites to structural metals. This program will yield information on the fundamental behavior of advanced composites and will provide a basis for selecting advanced composites for further studies aimed at applications in flight vehicles.

W74-70004 **501-21-20**
Langley Research Center, Langley Station, Va.
ADVANCED STRUCTURAL MATERIALS AND PROCESSES
George W. Brooks 703-827-2042

The objective is to determine the behavior and the suitability of advanced structural materials for aircraft applications, to investigate and develop advanced methods for fabrication and joining, to establish the effects of various environments on material performance, to determine possible changes in environmental resistance produced by fabrication methods, and to make metallurgical studies to characterize the nature and magnitude of the degradation produced by environmental exposures. The work will consist of research to establish the properties of materials exposed to simulated aircraft environments and will include analytical studies of diffusion, oxidation and creep. Research efforts will also focus on studies of advanced fabrication methods and on effects of fabrication on material properties as well as the application of nondestructive evaluation techniques to predict flaws or degradation of the materials. Studies will be made on the influence of high-speed air flow on the behavior of metallic specimens at high temperatures and on the stress corrosion of materials under various environments. These studies will provide information on the effects of various environments on the performance of structural materials and will produce results on the status of advanced fabrication methods and on nondestructive evaluation techniques.

W74-70005 **501-21-20**
Lewis Research Center, Cleveland, Ohio.
ADVANCED PROPULSION MATERIALS
J. C. Freche 216-433-4000
(501-01-06)

The objective of this RTOP is to provide improved materials, both metallic and nonmetallic, for use in advanced air-breathing power plants, particularly for aeronautical applications. Materials are sought that offer improvements not only in technical performance but also in economy in terms of costs and life. The classes of materials to be investigated include Ni- and Co-base superalloys, Fe-base alloys, titanium alloys, dispersion strengthened alloys, protective coatings, and refractory compounds.

Property improvements are sought by basic changes in materials per se, e.g., alloy compositional changes, and by process changes applied to existing and new materials. Material improvements are judged by the usual relevant property measurements. In addition, highly promising materials are evaluated by exposure to simulated gas turbine engines is accomplished by engine testing of components fabricated from newly developed materials. A program will be established in FY-74 that will accelerate the development of promising new engine materials and that will eventually lead to full scale engine testings of new materials.

W74-70006 **501-21-22**
Ames Research Center, Moffett Field, Calif.
POLYMERS
Glen Goodwin 415-965-5065
(501-38-19; 501-31-90; 743-31-01)

The objectives are to: (1) Synthesize and characterize novel polymers having improved physical and thermochemical properties over state-of-the-art materials for potential applications in advanced aeronautical systems. (2) Study and define the mechanisms of thermal, oxidative, hydrolytic and/or (photo) chemical degradation of these and other classes of polymers in order to establish limits for their performance under certain environments and eventually to design polymer structures having improved high temperature stability. (3) Study flammability and toxicology with emphasis on the mechanisms and kinetics of ignition, flame spread of polymeric materials, fire extinguishment, and toxicity of polymer pyrolysis products. Novel or modified polymers will be synthesized and characterized with respect to thermophysical and chemical properties. Emphasis will be placed on the synthesis of crosslinkable polycarbonate copolymers having superior heat, fire, radiation and impact resistance, and other polymers having high thermal-oxidative resistance. The mechanisms of degradation of certain classes of polymers will be investigated. This will include studies of thermal, oxidative, hydrolytic and/or (photo)chemical degradation of these polymer systems. The ignition and flammability of certain classes of polymers will be determined experimentally as well as through analytical modeling of flame spread. Toxicity of the pyrolysis and combustion products from these polymers will be determined.

W74-70007 **501-21-22**
Langley Research Center, Langley Station, Va.
POLYMERS
George W. Brooks 703-827-2042

The objectives are (1) to conduct research on the preparation of new high performance polymers for aeronautical applications; (2) to characterize the chemical, thermal, and physical properties of these polymers and relate the properties to molecular structure, and (3) to adapt and test appropriate polymers as coatings and adhesives. The approach will emphasize research on processable, thermally-stable polymers which retain good mechanical properties at high temperatures. New aromatic and heteroaromatic polymers will be synthesized or otherwise obtained and their molecular structures systematically varied to determine how well selected properties such as improved thermooxidative stability and processability can be built into high performance polymeric materials. To this end, exploratory leads already emerging from Langley's polymer research program will be pursued. The study will employ routine polymer characterization techniques such as spectrometry, viscometry, osmometry, thermogravimetric analysis with associated mass spectrometry, elemental analysis and melt rheology. New characterization methods including torsional braid analysis, automatic dielectrometry, and thermomechanical analysis will also be used, especially for determining softening and transition temperatures. A test program will be established to evaluate the effects of operating environment on polymeric adhesives and coatings. This information will lead to an understanding of the principles involved in developing adhesives and coatings, which in turn will define relationships between molecular structure and application properties and will direct future programs.

W74-70008 **501-21-21**
Lewis Research Center, Cleveland, Ohio.
FATIGUE, FRACTURE, AND LIFE PREDICTION
S. S. Manson 216-433-4000

The major objective is to obtain a better understanding of the failure or fracture mechanisms that are involved in the application of advanced materials to aeronautics structures or propulsion systems. A second major objective is to develop methods for predicting the life of specimens or components when they are subjected to constant temperature and monotonic loads or to complex patterns of temperatures and cyclic loads as a function of time. To achieve these objectives, research is underway to extend existing life prediction techniques and analyses, and to develop new methods for determining the stress and strain distributions in the vicinity of discontinuities such as flaws or cracks, as well as to understand the reaction of advanced materials to these discontinuities when subjected to various environmental conditions. Various approaches are also being examined for predicting the time to initiation of the first detectable cracks as a result of mechanical and thermal fatigue and to predicting the propagation rate of these cracks. Standard fracture test methods, NDE techniques, and specimens are being developed to properly characterize the fatigue and fracture behavior of materials and to provide background information for rational design procedures.

W74-70009 **501-21-21**
Ames Research Center, Moffett Field, Calif.
FATIGUE, FRACTURE, AND LIFE PREDICTION
Glen Goodwin 415-965-5065

This program is to investigate fatigue, fracture, and life prediction of materials through the study of the following programs: the prediction of time-dependent fracture of structural metals caused by subcritical crack growth, the study of the mechanics of fracture of fibrous composite materials, and the definition of stress-corrosion cracking of low and high alloy, high-strength steels in seawater environments. Experiments will be conducted on metals under conditions of static and cyclic loading in a variety of environments to determine the mechanisms and kinetics involved in the process of environmental embrittlement. Both experimental and analytical investigations will be conducted on fibrous composite materials to determine the relation of the properties of matrix, fiber, and interface to the failure behavior. Also, tests will be performed on alloy steels being considered for high strength aeronautical applications to correlate the effects of heat treatment and weld structure on stress-corrosion crack initiation behavior and crack growth kinetics.

W74-70010 **501-21-24**
Lewis Research Center, Cleveland, Ohio.
APPLICATION OF ENGINE MATERIALS
N. T. Saunders 216-433-6676
(501-21-20)

This program involves the application of new materials and manufacturing processes for aircraft turbine engines. It will cover the advanced development, rig, and engine testing necessary to demonstrate the potential of new materials technology for use in future engines. The program will be conducted primarily through contracts with domestic engine manufacturers and their vendors. New materials and processes that have shown laboratory feasibility in exploratory development programs (e.g., under RTOP 501-21-20) will be selected for further development and evaluation under this program. Cost/benefit and risk analyses will be conducted to help guide the selection of the best candidate materials. The selected materials will then be scaled up, manufactured into appropriate engine hardware, extensively evaluated to provide preliminary design data, and tested in both engine-simulation rigs and experimental engines to demonstrate their potential for future engine use.

W74-70011 **501-31-90**
Ames Research Center, Moffett Field, Calif.
FIRE RETARDANT MATERIALS FOR MILITARY PROGRAMS
Glen Goodwin 415-965-5065
(501-21-22)

The objectives are to: (1) utilize high temperature polymeric materials developed at Ames to support current DOD aircraft vulnerability/survivability programs and other military programs

where advanced materials are required for high performance aircraft; (2) provide consultation, technical data and to develop the necessary thermal, radiation and ballistic protection technology for survivability improvements of military aircraft; (3) assist the military in implementing this advanced materials technology in the design of new military aircraft and to apply these materials technology in existing aircraft and other weapon systems. Assistance will be provided to the Tri-Services to reduce the vulnerability of aeronautical systems in a non-nuclear threat environment. This will be accomplished by active participation in the DOD Joint Technical Coordinating Group on Aircraft Survivability, by improving and developing materials and concepts which could be utilized to enhance survivability and by providing technical data, engineering services and consultation to various military agencies as requested. The development of appropriate technology, its application and testing will be coordinated with the various DOD agencies.

W74-70012 **501-02-01**
Langley Research Center, Langley Station, Va.
ADVANCED CONCEPTS
George W. Brooks 703-827-2042

The objectives are to: (1) develop and demonstrate innovative composite concepts for improving the structural efficiency of lightly loaded structures; and (2) demonstrate the feasibility of using newly developed rectangular cross-section boron filaments instead of the conventional round filaments in laminated composite structures. In-house and university studies will be performed to identify methods of tailoring composite materials for lightly loaded structures. A university program will be formulated to develop, construct and test structures subjected to various combined loads. Candidate concepts are: stiffened skin, sandwich, stiffened sandwich, stiffened skin with tapered stiffeners, variable thickness sandwich, and concepts which take advantage of the coupling characteristics of composites. Under contract, a supply of rectangular boron filaments will be fabricated by the better of two processes developed with FY-73 funds. The rectangular filaments will be laminated into multiple-ply undirectional composite specimens whose cross-sections are similar in appearance to brick walls. The specimens will be tested in-house to determine the elastic constants and failure modes for such laminates. Use of rectangular instead of round filaments should improve the structural properties of laminated composite plates, particularly transverse to the fiber direction.

W74-70013 **501-22-04**
Langley Research Center, Langley Station, Va.
LOADS, AEROELASTICITY, AND STRUCTURAL DYNAMICS
George W. Brooks 703-827-2042

The objectives of research performed under this RTOP are to: (1) develop information and techniques for determining the loading, stress and response of practical flight structures exposed to turbulent fluid flow; (2)provide technology for the accurate prediction of flutter and other aeroelastic phenomena; (3) improve and validate aeroelastic loads analysis programs and assess aeroelastic effects on advanced flight structures; (4) develop new knowledge and techniques for predicting acoustic loads, response and fatigue characteristics of acoustically loaded flight-structure configurations; (5) establish methods for predicting the dynamic behavior of flexible aircraft and rotorcraft structures and develop design technology for structural dynamic systems; (6) improve capabilities of instrumentation utilized in wind tunnel aeroelastic models with emphasis on active control systems. The work will include in-house university grants and contractural efforts.

W74-70014 **501-22-05**
Ames Research Center, Moffett Field, Calif.
LOADS, AEROELASTICITY, AND STRUCTURAL DYNAMICS
H. M. Drake 415-965-5851
(502-22-11; 502-32-02)

The objective of this research is to provide improved prediction methods and data that apply to several dynamic load and aeroelasticity problems involving aircraft. In the area of dynamic loads, investigations will be conducted to study the flow fields and pressure fluctuations within and in the vicinity of cavities (such as open ports and bomb bays), protuberances, and turrets on aircraft. Means of eliminating cavity resonances and alleviating high-intensity local dynamic loads will be sought. With respect to aeroelasticity, both analytical and experimental investigations will be conducted to develop and validate computational methods for prediction of panel flutter including the effects of the boundary layer. Experimental investigations of unsteady pressures on oscillating semispan wings will be investigated at transonic speeds and studies will be conducted of the flutter and divergence of oblique wings.

W74-70015 **501-22-08**
Flight Research Center, Edwards, Calif.
FLIGHT LOADS MEASUREMENT TECHNIQUES
J. M. Jenkins 805-258-2453

This RTOP will cover the work being performed toward advancing flight loads measurement techniques for high-speed aircraft. Specifically, a current problem is that of avoiding the fatigue - sensitive attachment characteristics associated with spotwelding weldable strain gages to titanium structures. The weldable strain gage is the most advantageous type of strain gage for high temperature application. The resources of this RTOP will be directed toward developing, under R and D contract, a method to accomplish a metal-to-metal attachment for weldable strain gage configurations to titanium structures.

W74-70016 **501-22-10**
Langley Research Center, Langley Station, Va.
SUPPORT OF DOD IN BALLOON ENGINEERING
George W. Brooks 703-827-2042

One objective of this program is the development of equipment at LRC for measuring the biaxial structural characteristics of fabrics and films under controlled environments. A cylindrical test apparatus will be developed that provides axial, circumferential and torque loads in either cold or hot environments and will include real time data processing. A second objective is to procure and test new tethered balloon laminates using a structural matrix of PRD-49 cloth and employing improved adhesives. The substitution of PRD-49 for Dacron and the use of aliphatic polymids or polybutadiene triisocynates adhesives is expected to yield greater strength and improved low temperature performance. A third objective is to develop an adhesive with adequate ductility at extremely low temperatures while being free of tackiness at warm temperatures. This is being conducted by a University grant with Princeton. A fourth effort is the thermal characterization of laminates and films used in balloon construction and the study of methods and system effects of modifying these characteristics.

W74-70017 **501-22-11**
Langley Research Center, Langley Station, Va.
STRUCTURAL ANALYSIS AND DESIGN METHODS
George W. Brooks 703-827-2042

A basic capability is developed for the analysis and automated design of aerospace shell structures. Nonlinear phenomena analytically and experimentally in support of design of shuttle structural components are studied. NASA will be provided with a plan for implementing NASTRAN on the CDC STAR computer. Continue development under contract of the field method of structural analysis and implement in a computer code (SRA) for detailed stress analysis, vibration characteristics and stability analysis of complex branched, rotationally symmetric shells subjected to mechanical and thermal loads. Under contract improve a code (STAGS) which determines the linear and nonlinear stress analysis and collapse loads for a general two-dimensional shell structure. Add to this code vibration capability and hybrid finite-difference finite-element capability. Exercise codes in-house on shuttle related problems and other problems of interest. Conduct experimental investigation of the stability of both stiffened and unstiffened shells with unreinforced and reinforced cutouts to validate the codes and provide phenomenological data to guide studies of complex configurations. Introduce structural resizing and optimization procedures into existing structural analysis programs to provide automated design capability. Under

contract an assessment will be made of the impact of fourth-generation computers on NASTRAN.

W74-70018 **501-22-13**
Langley Research Center, Langley Station, Va.
DRONE FLIGHT PROGRAM
George W. Brooks 703-827-2042

The objective is to provide flight data for comparison with results from various prediction techniques as a means of validating the prediction techniques. For cases where analyses are known to be inadequate, obtain flight test data for definition of aerodynamic loads, especially in off-design conditions. In order to accomplish these objectives, adequate flight testing techniques will be developed utilizing drone-type vehicles as efficient data-providing media. The principal areas of interest are the aerodynamic loads measurements (pressure distributions, shear, torque, and bending moments) with the related studies of active control systems, composite materials, and stability and performance for flight in both steady and unsteady (turbulence) aerodynamic flow and for subsonic, transonic, and supersonic speed ranges. An ongoing flight series will be completed and a specific flight loads experiment implemented.

W74-70019 **501-22-02**
Langley Research Center, Langley Station, Va.
STRUCTURAL INTEGRITY
George W. Brooks 703-827-2042

This work covers several essential elements of a comprehensive, long-range plan to advance the science and technology of aerospace structural design toward conditions of optimum reliability, efficiency, and economy, while shortening the design time required. The ultimate goal is to develop a fully automated procedure for design. At present, three essential factors in the design process (fatigue, fracture, and nondestructive evaluation) rest on a technology-base that is seriously behind the conjoined technologies for static strength and aeroelastic analyses. Consequently, fatigue, fracture, and NDI are the weakest links in the chain of design, and as such, demand special attention and high priority. The individual tasks here embrace a balanced mix of theoretical and experimental approaches which range from mathematically based models of fatigue and fracture phenomena, through the generation of urgently needed engineering data, to the conception, construction, test and evaluation of new structural concepts. To the degree possible, the work anticipates the design problems and materials that will be encountered by the space shuttle, satellites, advanced subsonic and supersonic transports, rotary-wing aircraft, and vertical- and short-take-off-and-landing aircraft. The ongoing research includes such studies as ways to deal with stress concentrations, growth of cracks in complex structures, size effects, load histories, environmental effects, nondestructive testing, and economical ways to monitor cyclic strains in aircraft during service.

W74-70020 **501-22-06**
Langley Research Center, Langley Station, Va.
HYPERSONIC VEHICLE STRUCTURES
George W. Brooks 703-827-2042

Research and development is being carried out to establish a technology base from which the structures and thermal control systems for hypersonic vehicles can be designed. Included in the program are both experimental and analytical efforts on engine and airframe structure concepts which will withstand the rigors of extended and repeated use in a hypersonic environment. Research data obtained from experiments will serve to verify design and analysis methods and to establish design guidelines.

W74-70021 **501-22-06**
Flight Research Center, Edwards, Calif.
HYPERSONIC VEHICLE STRUCTURES TECHNOLOGY
Roger A. Fields 805-258-2748

The program will attempt to experimentally validate significant hypersonic-vehicle structural concepts and investigate flight-loads measuring techniques for these structural concepts as they apply to the HRA.

W74-70022 **501-22-03**
Langley Research Center, Langley Station, Va.
COMPOSITE MATERIALS APPLICATION TO AIRCRAFT STRUCTURES
George W. Brooks 703-827-2042
(501-21-23; 766-74-01)

The objective is to conduct research on composite materials to resolve problems that may hinder their application, to develop the technology required for their utilization in future aircraft structures, and to establish confidence in the use of composites through longtime flight service of structural components on commercial transport aircraft and Army helicopters. The work consists of the following: (1) develop analytical methods to improve understanding of composite materials; evaluate behavior under various environmental conditions; develop concepts, fabrication, and nondestructive evaluation technology, (2) develop new design methods and generate supporting test data to provide reliable design allowables for composite structural elements and components; (3) fabricate and test critical components to demonstrate performance; (4) conduct engineering studies to determine applicability of composites in primary or secondary structures of commercial or military aircraft; and (5) develop applications to operational aircraft such as the CH-54B helicopter, 737, L-1011, and DC-10 commercial transports. Both in-house and contractual efforts will be undertaken. The results of these studies will provide new technical information and flight-service experience that will develop confidence required to permit early application of filamentary composites in aircraft structures.

W74-70023 **501-03-01**
Wallops Station, Wallops Island, Va.
AIRCRAFT TERMINAL AREA VISIBILITY STUDIES
A. C. Holland 703-824-3411

The technical objective is to determine the mechanisms that affect visibility in the atmosphere. The approach will be to: (1) develop a mathematical model and perform simulation and analysis of atmospheric transmission mechanisms; (2) evaluate this model under real world weather conditions using polar nephelometers, transmissometers, holographic cameras or other suitable instrumentation; and (3) produce a report covering the results of this research.

W74-70024 **501-03-02**
Langley Research Center, Langley Station, Va.
JOINT UNIVERSITY PROGRAM ON AIR TRANSPORTATION SYSTEMS
G. B. Graves 703-827-3745
(776-75-02; 768-81-01; 791-93-51; 768-81-02)

The primary objective is to foster development of a university research capability across the disciplines that involve the avionics and flight control systems of aircraft and their interaction with the air traffic and airport airside operating environments. A secondary objective is to encourage university interest in interdisciplinary education that will provide engineers and scientists capable of attacking the system problems involved in these areas of air transportation. The pilot program established last FY will be continued at the same level. Efforts to further improve communications and interactions between the schools, and to foster initiation of complementary research projects will include joint quarterly meetings of the principal investigators, the production and exchange of video recordings of technical lectures, and the extension of the contract between Litchford Systems, Inc., and the universities for program coordination.

W74-70025 **501-03-11**
Ames Research Center, Moffett Field, Calif.
APPLICATION OF CONTROL AND GUIDANCE THEORY TO THE AUTOMATIC AND MANUAL CONTROL OF FUTURE STOL AND VTOL AIRCRAFT
Bradford H. Wick 415-965-5567
(768-83-01)

The purpose of this research is to apply modern control theory techniques to the problem of control and guidance of STOL and VTOL aircraft, and to extend control theory for the development of new techniques as needed. Consideration will be given to the definition of the mission and to the vehicle

environment, including ATC and navigation aids, atmospheric and gust effects, and aircraft noise. Models of the aircraft and its subsystems must be developed for a variety of flight modes and these models used for analysis and synthesis of STOL and VTOL aircraft guidance and control systems. The resultant models, along with suitable analysis and synthesis techniques, will be applied to the synthesis of a complete control and guidance system for STOL and VTOL aircraft. The resultant 4-D guidance system will be tested through simulation and as a flight experiment on STOLAND, and autopilot designs will be tested for pilot acceptability. As the analysis and synthesis of STOL and VTOL systems procedes, it becomes apparent that new or improved mathematical theories are needed to improve the design procedure. Research will be conducted, largely through the grant and research associate programs, to provide these new and improved theories, and to demonstrate their applicability to the ongoing STOL and VTOL system designs.

W74-70026 **501-23-11**
Langley Research Center, Langley Station, Va.
AUTOMATED AVIONICS FOR VTOL
G. B. Graves 703-827-3745
(768-81-06; 766-75-02; 760-63-04)

This effort will define and develop the advanced avionics technology required for reliable, all-weather operations of a viable short-haul transportation system in the 1980s. Technology developed under this RTOP along with coordinated efforts in aeronautics (760-63-04) and operating systems (768-81-06) are the major elements of an integrated LRC program with the ultimate goal to develop and demonstrate operational capability of VTOL as a short-haul transportation system. The navigation, guidance, and control requirements for enroute, terminal area, and approach and landing of VTOL aircraft will be determined with emphasis on automatic operations. New technology will be used to develop low cost and reliable radio-inertial navigation systems, displays, sensors, and hemispheric coverage landing guidance systems. Designs of functionally integrated systems will be implemented in prototype hardware for specific VTOL aircraft and flight tests will be conducted to evaluate and demonstrate systems performance. VTOL guidance, navigation, and control requirements, and concepts will be investigated by extending previous analytical studies, simulation, and flight experiments to include automatic flight and landing operations.

W74-70027 **501-23-21**
Flight Research Center, Edwards, Calif.
GENERAL AVIATION FLIGHT CONTROL SYSTEM AND DISPLAYS
M. R. Barber 805-258-3311
(760-60-05)

This program is a coordinated effort to provide avionic system technology, development and criteria that will continue the improvements in safety and utility of all aircraft, particularly general aviation type aircraft. Various new concepts in flight control, navigation, and display systems are being investigated through the use of simulators and flight vehicles that will reduce the pilots workload and enhance his performance by applying human factors engineering to system design. Emphasis will be on low cost designs for general aviation.

W74-70028 **501-23-31**
Langley Research Center, Langley Station, Va.
HIGHLY RELIABLE CIVIL AVIATION COMPUTING SYSTEMS TECHNOLOGY DEVELOPMENT
G. B. Graves 703-827-3745
(766-75-02; 501-23-32)

New digital computer architectural concepts, techniques, and advanced technology will be investigated and developed to improve the reliability and fault tolerance of digital computers. Hardware redundancy, software diagnosis, and self-test and repair will be used to improve computer availability during flight, thereby advancing flight safety and promoting pilot confidence of critical electronic systems. Proposed organizational concepts will be assessed using computer-aided reliability estimation techniques to determine relative merits. Architectures originated in-house proposing the use of off-the-shelf computers will be evaluated and selection made; experimental laboratory hardware and software will be developed; analysis will be performed relating these to other architectures, and practical implementation problems studied. Results will be applicable to Digital Fly-By-Wire program, VALT, TCV, and AST programs.

W74-70029 **501-23-32**
Langley Research Center, Langley Station, Va.
ACTIVE CONTROLS TECHNOLOGY
G. B. Graves 804-827-3745
(501-26-05; 766-75-01; 766-75-02)

The objectives are to: (1) provide the design guidelines and prediction techniques and the demonstrated performance to ensure readiness for incorporation of high-payoff ACT design concepts in future aircraft offering significantly increased economic and performance benefits and design flexibility; (2) provide a technology base for the integrated design and flight control systems capability needed for early implementation of ACT concepts. The approach will be through contract and in-house studies, develop analytical and empirical techniques required for the prediction of aerodynamic and aeroelastic characteristics of ACT aircraft; develop guidelines and criteria for individual and integrated combinations of active control concepts; establish requirements for hardware components and derive algorithms that minimize sensitivity of the control system to uncertainties in aircraft parameters; conduct functional flight demonstrations of near-term ACT concepts on a light-wing-loading STOL aircraft and on the NASA S-737 Terminal-Configured Vehicle aircraft to investigate ACT operational compatibility and effectiveness; and conduct concept demonstration flight tests of high-risk ACT concepts with a remotely piloted research vehicle (RPRV) featuring a transport category design load factor and a structure designed to reduced strength and stiffness requirements.

W74-70030 **504-09-05**
Ames Research Center, Moffett Field, Calif.
PILOT TRAINING RESEARCH
H. P. Klein 415-965-5094
(501-29-02; 501-29-03; 501-29-01)

The overall objective of this RTOP is to develop specifications for an advanced general aviation pilot training system that will meet all training requirements for the 1980s. Specific objectives are: (1) survey current pilot training practices and identify deficiencies, (2) project general aviation pilot training requirements for the 1980s, (3) develop appropriate training and performance measurement technology to meet and anticipated requirements. The program is anticipated to extend over a five year period. Primary emphasis is upon an in-house R and D program which will be supplemented where necessary by contract support. It is recognized that a highly cooperative inter-agency effort is essential for valid problem assessment and timely implementation schedules; accordingly every stage of the program will be specifically coordinated with relevant DOT, DOD, and industry groups.

W74-70031 **504-09-02**
Langley Research Center, Langley Station, Va.
HUMAN RESPONSE TO THE AERONAUTICAL ENVIRONMENT
George W. Brooks 703-827-2042
(501-29-11)

The objective of this work is to further the understanding of the psychophysiological effects of aircraft noise on people and to develop a quantitative understanding of individual response to noise exposure. This objective includes the development of research evaluation techniques and measuring scales along with accomplishment of research to assess effects of noise on sleep, subjective reactions, and hearing. Emphasis will be placed on laboratory studies with complementary studies in communities exposed to noise and with special overflight programs where selected juries are exposed to noise. Studies will be concerned with responses of people during both awake and sleep periods and under background noise conditions associated with outdoor, indoor, and inflight situations. Laboratory studies will be complemented by residential studies to obtain basic information on responses of people living near airports. Studies will evaluate

both auditory and non-auditory effects of low frequency noise (below 300 Hz) on people. The development of methods for conducting meaningful laboratory tests will be directed toward obtaining improved stimuli presentation and improved subjective response measures. Included will be studies to generate testing methods and procedures to be used in the new Aircraft Noise Reduction Laboratory. Studies will be conducted to evaluate hearing threshold shifts and will include effects ranging from temporary hearing effects to ear damage. Studies will be initiated to develop a program to further the understanding of responses of people to sonic booms with special attention to low level sonic boom exposures.

W74-70032 **504-29-01**
Ames Research Center, Moffett Field, Calif.
ACCEPTANCE OF AIRCRAFT OPERATIONS - TECHNOLOGY ASSESSMENT
H. P. Klein 415-965-5094

The objectives of this program are to develop an understanding of the social effects of large scale technological innovations, as exemplified by short-haul air transport systems, and to design technology that will lead to improved safety and comfort of aircraft crews and passengers. Studies of both the short and long term social impacts (including psychological, political, environmental, and economic) of short-haul air transport as an element of the total transportation system will be continued. Field studies of existing systems and laboratory studies of specific impact phenomena will be included as needed to meet the objectives.

W74-70033 **504-29-01**
Ames Research Center, Moffett Field, Calif.
ACCEPTANCE OF AIRCRAFT OPERATIONS - TECHNOLOGY ASSESSMENT
H. P. Klein 415-965-5094
(741-72-06)

The objectives of this program are to develop an understanding of the social effects of large scale technological innovations, as exemplified by short-haul air transport systems, and to design technology that will lead to improved safety and comfort of aircraft crews and passengers. Studies of both the short and long term social impacts (including psychological, political, environmental, and economic) of short-haul air transport as an element of the total transportation system will be continued. Field studies of existing systems and laboratory studies of specific impact phenomena will be included as needed to meet the objectives. Designs of the Ames liquid-cooled helmet for aircrew thermal protection, and the Ames seat/restraint system, for passenger comfort and safety, will be modified as necessary to meet the requirements of potential users.

W74-70034 **504-29-11**
Langley Research Center, Langley Station, Va.
ACCEPTANCE OF AIRCRAFT OPERATIONS - COMMUNITY NOISE
George W. Brooks 703-827-2042
(501-09-02)

The objective of this work is to evaluate (1) noise characteristics of advanced VTOL and STOL aircraft, (2) acoustic retrofit systems for CTOL aircraft, and (3) noise alleviation procedures for aircraft and airport operations. This work will provide criteria for the prediction of community acceptance of aircraft operations/airport community noise. Emphasis will be placed on laboratory studies and airport-community studies/surveys which may be supplemented by programed overflight studies. These studies will be closely interrelated with/or in support of NASA Project activities (STOL) and with the DOT/FAA (acoustic retrofit) and PONYA (DPRS) in programs to control aircraft and airport noise. The laboratory techniques employed will range from listening room testing with trained subjects to real life situations where test environments represent the airport-community/home and where the test subjects may be people plagued by aircraft noise. Survey programs will be initiated to improve and validate annoyance predictive equations and to provide data for presenting this information in a handbook form. Further studies will be made to evaluate the potential of alleviating airport-community noise exposure by means of runway selectivity based on dynamic preferential runway systems which have shown considerable promise in initial operations at JFK International Airport.

W74-70035 **504-29-12**
Langley Research Center, Langley Station, Va.
RIDE QUALITY
G. B. Graves 703-827-3745
(743-36-13)

The objectives are to establish the aspects of airplane flight that are critical to passenger acceptance of the quality of the ride experienced, to establish criteria useful in the design of aircraft and ride-smoothing systems, and to establish limits in procedures or aircraft operations, particularly in terminal areas, so that the ride is generally acceptable. A research program is in progress which involves field studies using currently scheduled airline systems. The flight characteristics of the aircraft and subject responses to the ride experiences are being measured. A simulation program is planned using three Langley simulators whose characteristics are such that frequencies of motion and vibrations ranging from less than 1 Hz to 35 Hz will be investigated. The visual aspects will be an inherent part of the simulation studies. Subjects and motions used and experienced in the field studies will be used and the elements of the motion critical to ride acceptance will be isolated. Field studies using one or more airplane simulators, such as the Total In-Flight simulator (TIFS) at Calspan, will be performed to verify the findings of the ground based simualtions and the analysis of general flight studies, and to investigate ride-quality factors which cannot be readily simulated using ground based laboratory equipment. These experiments will be used for the establishment of an evolving set of criteria for ride smoothness requirements and operational limits as they regard airplane attitude, acceleration, and angular motions.

W74-70036 **504-29-21**
Flight Research Center, Edwards, Calif.
ACCEPTANCE OF AIRCRAFT OPERATIONS - RIDE QUALITY
W. R. Winter 805-258-3311
(501-09-03)

This flight test program investigates the relationship of vehicle motion to passenger comfort. A variable stability aircraft provides the necessary in-flight control of vehicle motion and conditions from which an assessment of passenger ride quality can be made. The program will validate some existing simulator data and will provide flight data in new areas which are beyond most groundbase simulator capabilities. The effort is coordinated with other Government agencies and industry for the purpose of having a common basis and understanding from which ride quality criteria may be established.

W74-70037 **504-29-02**
Ames Research Center, Moffett Field, Calif.
FLIGHT MANAGEMENT SYSTEMS
H. P. Klein 415-965-5094
(501-29-03)

This program will investigate flight management and crew/system interaction mechanisms and requirements for advanced aircraft. The program will develop working specifications for a fully integrated airborne flight system to be fabricated and flight tested by the end of the decade. Special attention will be given to safety, human factors, and full system simulation. The objectives are: (1) determine system/pilot communication requirements (especially CRT displays) for aircraft flight management in the 1980's. Define the content, format, location, function, and pilot procedures for such displays. (2) Determine pilot/system communication requirements and device specifications for entering alphanumeric data and system commands. (3) Integrate the results of objectives 1 and 2 in the design of a flight deck system for commercial transport application. (4) Fabricate and flight test an integrated flight deck to demonstrate operational utility. Full-flight integrated cockpit simulation is being developed in the Ames Biotechnology Simulation Facility that involves piloted full mission profiles from takeoff to landing. The simulation development is an in-house effort with some contracts to provide necessary

computer programming and supportive studies as required. Evaluations will be made of the effects of the pilot-system interface and cockpit environment on: (1) the pilot's ability to be constantly apprised of past, present and (predicted) future system status; (2) the pilot's ability to monitor the system for exceeding performance tolerances or system failures; and (3) the pilot's ability to make decisions and execute them in an accurate and timely manner.

W74-70038 **504-29-13**
Langley Research Center, Langley Station, Va.
FLIGHT MANAGEMENT SYSTEMS
G. B. Graves 703-827-3745
(768-81-02)

The proliferation and increasing complexity of flight deck crew tasks (such as aircraft systems monitoring and control, traffic control, collision avoidance, etc.) makes it mandatory to keep these functions within the crew's workload capacity - with a reserve margin for emergency situations. The task is to develop techniques for optimizing crew functions at both the systems and subsystems levels. The objective is to apply these techniques to the definition of efficient systems for advanced aircraft. A specific application will be the development of optimal instrument and display arrangement for precise 4-d terminal area maneuvering of transport aircraft. This will be a cooperative effort with the TCV program. Previous approaches have been primarily on an ad hoc, subjective basis resulting in a multitude of competing systems and procedures. The necessity for less confusion and conflict and for more standardization for the complex aircraft - air traffic control systems of the future requires the application of objective methods for the design and development of optimal instruments, displays, and cockpit procedures. Therefore, this RTOP will concentrate on the following: (1) Development and validation of objective measurement techniques for determining workload under realistic conditions, as opposed to constrained and often-encumbered laboratory situations. Crucial to this activity is the application of the oculometer and development of on-line oculometer data analysis procedures. For example, complete---

W74-70039 **504-29-03**
Ames Research Center, Moffett Field, Calif.
SIMULATION TECHNOLOGY FOR AERONAUTICS - PILOTING CUES
H. P. Klein 415-965-5094
(501-29-01; 501-29-02; 501-29-05)

The objectives of this program are to: (1) provide information for simulator engineers about the pilot's perception of complex stimuli, including motion cues, visual display cues, and outside scene visual cues; (2) provide evaluations and engineering development of computer graphic displays, including color systems, high contrast CRTs, and electronic fog systems; and (3) provide a simulated ground station for RPV systems analysis and display/control evaluations. During FY-74, (1) in-house pilot perception studies will be conducted, (2) a computer graphic color system will be evaluated, and (3) RPV ground station development and research will be conducted with FRC. Contract activities will continue at San Jose State College and Scripps Institution of Oceanography to support this program.

W74-70040 **504-29-14**
Langley Research Center, Langley Station, Va.
FLIGHT SIMULATION TECHNOLOGY - PILOTING CUES
G. B. Graves 703-827-3745
(501-39-11)

The objective of this research is to obtain the knowledge required to produce valid simulation of crew tasks in controlling vehicles under typical flight conditions while minimizing the complexity of the simulation equipment. Primary factors to be considered include the detail, resolution, and field-of-view of visual systems, the amount of motion and dynamic motion response, and the influence of other environmental factors such as noise. Existing simulators will be used to study vision and motion cue requirements for a range of flight conditions so that a better understanding can be obtained of the vision-vestibular system. The Real-Time Dynamic Simulator (RDS) is being used to study large-amplitude, low-frequency motions. The Vision-Motion Simulator (VMS), which incorporates a visual display mounted in a cockpit capable of rapid motion about all axes, will be used to investigate maneuvers involving higher frequency motions. In addition, attention will be given to evaluation of the factors involved in the use of simulators for training; here, the approach is to benefit by analysis of ongoing simulation work at Langley, including programs in the Differential Maneuvering Simulator (DMS).

W74-70041 **504-39-01**
Ames Research Center, Moffett Field, Calif.
SIMULATION TECHNOLOGY FOR AERONAUTICS - SYSTEMS
George A. Rathert, Jr. 415-965-5168
(501-29-03)

Research on flight dynamic problems in simulation facilities requires faithful duplication of control forces and force gradients. Research involving convertable VTOL aircraft requires a range of force characteristics for both conventional flight and for hovering flight that are not generally obtainable from conventional control loaders because of inherent design details. Funding was provided in FY-72 to obtain a new type of rotary control loader that would eliminate many of the problems found in existing loader systems. The new rotary loaders were delivered in late FY-73. This RTOP is intended to evaluate the rotary control loaders and to develop the techniques for their application to the various control systems required in multi-purpose manned simulators.

W74-70042 **504-39-11**
Langley Research Center, Langley Station, Va.
FLIGHT SIMULATION TECHNOLOGY - SIMULATION TECHNIQUES
G. B. Graves 703-827-3745
(501-29-14)

Computer based flight simulation studies permeate all phases of aerospace technology development, from conceptual design through pilot training. The alliance of flexible simulator hardware with high-speed computing equipment represents a research approach to problems that could not otherwise be practically solved. The objective of the work under this RTOP is to provide substantial improvement in NASA's capability for flight simulation through the integration of the specialized simulation aspects of computer science, applied mathematics, optics, and servo-mechanisms. Emphasis will be placed on computer techniques for visual scene generation to remove the field-of-view restrictions which encumber present systems. Effort will be undertaken on advanced mathematical and computing techniques to permit a high degree of simulation fidelity within reasonable computer memory and speed limitations. This also includes work on optimal strategies to handle the onset and washout cues to simulate flight motions within the limited displacements which are practical for ground simulators. Development and procurement will be undertaken on specialized systems which are capable of providing general support to a broad spectrum of aeronautical research programs where it has not been practical to support these efforts by individual program funding.

W74-70043 **501-04-01**
Lewis Research Center, Cleveland, Ohio.
BASIC NOISE RESEARCH
E. W. Conrad 216-433-6369
(501-24-01)

This RTOP covers work directed toward understanding the principles and phenomena involved in the generation, propagation, and suppression of turbomachinery, jet, and jzt-surface interaction noises. In addition to several in-house analytical and experimental efforts, a series of grants and contracts will be awarded to conduct a coordinated basic noise research program. This program is structured to permit aero-acoustic specialists to carry out investigations of several years duration, if appropriate, in several noise areas. This work is directed toward providing a broad, firm base of understanding and knowledge and, evolving from that base, ways to improve noise prediction methods and design procedures for quieter engines and acoustic nacelles.

W74-70044 **501-04-01**
Langley Research Center, Langley Station, Va.
BASIC NOISE RESEARCH
George W. Brooks 703-827-2042
(501-24-01)

The objectives are to obtain improved understanding of the fundamentals of generation, propagation, and suppression of noise of gas turbine power plants of commercial, general aviation, and military CTOL aircraft under various operating conditions and for which such components as exhaust jets, burners, blades, and vanes are significant noise sources. The objectives include the identification of noise generation mechanisms, development of methods of predicting radiated noised, and the identification and evaluation of approaches to noise reduction. Both theoretical and experimental studies are involved and work will be accomplished in-house and under contract. Emphasis is placed on substantially improving analytical and experimental methods as well as equipment and facilities for subsonic and supersonic jet noise research. Jet exhaust noise studies will be performed in-house on small models to correlate measurements of the flow field with near field and far field acoustic measurements in order to locate the actual noise sources inside the jet, evaluate their strength, and define their directivity. The basic subsonic acoustic and flow field measurements and theoretical studies for a simple circular jet are essentially complete whereas comparable studies for the supersonic case are just getting underway. Work will continue on related research involving wing surface shielding, the effects of forward velocity, nozzle configurations, sound speed profiles, and the definition of optimum jet exhaust noise suppressor designs. The effects of the atmosphere on noise propagation from air to ground for stationary and moving sources, and for both linear and nonlinear situations will be studied using a high instrumented tower.

W74-70045 **501-04-01**
Ames Research Center, Moffett Field, Calif.
BASIC NOISE RESEARCH
H. M. Drake 415-965-5066
(501-06-13)

This research is directed at improving the understanding of the fundamentals of aerothermodynamic noise generation and propagation. The primary objective is to develop improved and/or new methods for prediction of airfoil generated noise and noise generated in jet exhausts. The research will involve both analytical and experimental studies of aerodynamic noise generation in propulsion and lift producing fluid flows. This RTOP also covers research on turbulent mixing noise at forward speed, in relatively large scale jets. The understanding of turbulent mixing noise from static jets is not complete, while the effect of forward speed is less understood. In order to predict jet noise, it is necessary to bring about a better understanding of that part of the turbulent mixing that produces noise. This will be done by measuring turbulence in large scale jets with laser-Doppler velocimeters (two). These measurements will be correlated with themselves and with far field acoustic measurements to define the characteristics of the turbulence, and of that turbulence which produces noise in the far field.

W74-70046 **501-04-01**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
BASIC NOISE RESEARCH
Rob R. McDonald 213-354-6186

The general objectives of this RTOP are (1) to characterize the density fluctuations and obtain a relationship between the density fluctuations and the intensity and frequency spectrum of the noise radiated from supersonic jets; (2) to determine how core flow disturbances increase the radiated noise from jets with the ultimate goal of developing efficient means of reducing jet noise emission by reducing core flow disturbances; and (3) to compare and clarify results obtained with different types of instruments that are used for measuring fluctuating quantities in jet flows. Experimental measurements of the preceptive noise level are made with pairs of microphones at selected locations in the surroundings of high temperature jets emerging from a nozzle. Crossed laser beams, set up as a schlieren system, are projected through the jet to acquire information that characterizes the fluctuating density. The convective velocity of the moving eddies and the autocorrelation of the fluctuating density in the moving frame of reference of the eddies are evaluated. The relationship between the fluctuating density and the noise is established from the respective autocorrelation functions. The tests are conducted in an anechoic chamber. The following major effects of core flow disturbances on the generation of noise radiated from a supersonic jet will be examined: (1) the oscillation of the inviscid jet boundary and Mach wave structure, (2) the effect on the mixing layer structure (particularly large scale eddies), (3) shock wave oscillation, and (4) entropy fluctuation interactions. Available theories will be examined with particular attention focused on scaling properties of the different disturbance-noise interaction processes. The disturbing influences to be studied include oscillating pressure, composition and temperature.

W74-70047 **501-04-02**
Langley Research Center, Langley Station, Va.
BASIC POLLUTION RESEARCH
Eugene S. Love 703-827-2893

Experiments are being conducted to obtain a better understanding of the influence of kinetics, temperature, pressure, nature of hydrocarbon fuel, and turbulence on the production of gaseous and particulate pollutants with emphasis on nitric oxide and soot formation. These studies will be made using laboratory flame burners and a shock tube to produce well characterized combustion environments. A mathematical description will be developed of the interaction of combustion emissions from aircraft with the stratospheric environment. The mathematical model will be concerned with the wake region in the immediate vicinity of the aircraft and will incorporate kinetics, mixing, and the spare time variation of the concentration of the reactants. Experimental and theoretical investigations will be conducted on the scattering characteristics of the aerosol layers associated with the lower stratosphere. Optical radar measurements will be made for comparison with the in situ measurements (overguideline item).

W74-70048 **501-04-02**
Lewis Research Center, Cleveland, Ohio.
BASIC POLLUTION RESEARCH
Richard A. Rudey 216-433-6160
(501-24-02; 501-24-18)

The concentration of various particulate and gaseous pollutants in the region of the atmosphere between 20,000 and 40,000 feet will be measured by employing sampling devices on commercial air transports. These measurements will be used to establish baseline data on the contaminants in the atmosphere in order to deduce the contribution of jet aircraft to atmospheric pollution, and basic studies will be conducted to develop and better understand the factors involved in the formation and dispersion of jet engine pollutants. This information may then be used to determine the necessary steps required to reduce pollution by jet aircraft. Components to be measured include hydrocarbons, carbon monoxide, oxides of nitrogen, oxides of sulphur, ozone, water vapor, and total particulates.

W74-70049 **501-04-02**
Ames Research Center, Moffett Field, Calif.
PRODUCTION AND DISPERSION OF POLLUTION FROM JET AIRCRAFT
Glen Goodwin 415-965-5065
(743-34-22; 160-44-79)

The objective of this research is to provide basic models of jet aircraft engine pollution and wakes for use in the assessment of the impact on the atmosphere of jet-powered aircraft operations. The models will be used to support the Stratospheric Jet Wake Experiment and will, in turn, be modified by the experimental data obtained in that flight experiment. Production of pollutants from jet aircraft engines is being studied by computer modeling of the chemically reacting flow through the engine, and the subsequent dispersion and chemistry in the wake. Hydrodynamic dispersion models of the wake will be combined with the chemical models to describe the concentrations and distributions of exhaust products within the wake for long distances behind the aircraft. Sets of chemical reactions with appropriate reaction rates are being provided to the chemical models. Because basic

equation sets have already been developed and integrated into the model, special emphasis is now being applied to organic reactions and their rates which may influence exhaust chemistry. The models will be used to describe the chemistry and wake dynamics of the YF-12 aircraft in support of the Stratospheric Jet Wake Experiment.

W74-70050 **501-04-02**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
BASIC POLLUTION RESEARCH
Rob R. McDonald 213-354-6186

In Part 1, photochemical processes related to pollution of the upper atmosphere by high-flying aircraft are being studied, with emphasis on the effects of such pollutants on the stability of the ozone layer. The work is experimental in nature and involves laboratory measurement of steady-state ozone concentrations under simulated stratospheric conditions. The NO emission from conventional aircraft gas turbines increases as operational combustion temperatures continue an increasing trend. The overall goal of Part 2 of this RTOP is to demonstrate how this emission can be minimized by judicious control of fuel-air mixing and thermochemistry. The near term objective is to evaluate the potential for significant NO reduction for such unconventional design concepts as increased fuel atomization, fuel prevaporization and premixing, product gas recirculation, staged combustion, nonadiabatic combustion, and various combinations of these. Initially, design studies will be made to delineate the impact of these concepts on NO and other pollutants. Analyses will emphasize mixing, and chemical equilibria/kinetics effects in attempting to exploit the relatively slow NO reaction. Ultimately, combustion experiments will be performed to verify the validity of the analytical results and to develop design criteria. Finally, experimental demonstrations of minimum emission combustor configurations will be performed.

W74-70051 **501-04-03**
Ames Research Center, Moffett Field, Calif.
BASIC PROPULSION RESEARCH
H. M. Drake 415-965-5851

This effort is a continuation of the work to investigate advanced hypersonic inlet flow fields. The major objectives are to conduct coordinated experimental and analytical studies of hypersonic inlet flows in which the effects of coupling and analytic studies of hypersonic inlet flows in which the effects of coupling between the inlet, fuel injection system, and combustor will be evaluated, and in which fuel injection and combustor pressure rise are simulated so that the effects of these factors on mixing, flow distortion, and inlet performance can be determined. A body of detailed internal flow data, urgently needed to enable assessments of analytical methods, will be obtained. The study will be conducted utilizing both in-house and contract efforts, and will be conducted in phases.

W74-70052 **501-04-03**
Lewis Research Center, Cleveland, Ohio.
BASIC PROPULSION RESEARCH
Walter O. Logan, Jr. 216-433-4000

The object is to conduct basic research in fluid physics relevant to areas of interest to Lewis propulsion and power generation programs. Three universities are involved, each with their own contributing program. They are Case Western Reserve University, Massachusetts Institute of Technology, and the California Institute of Technology. The coordination of the research with Lewis is enhanced by visits of the professors to Lewis and corresponding visits of the grant monitor and other personnel to the universities. Former outstanding Lewis employees are associated with the grants at each of the schools. At CWR most of the efforts are originated through contacts with Lewis personnel. They include oscillating jets, film seals for self-acting lift pad seals, laminar boundary layer stability on heated plates, heat pipe theory, and steady and unsteady flame and combustion studies. At MIT the principal effort is in transonic compressor research, including blade flow theory, compressor experiments, and noise generation studies. The CIT studies include a new theory of compressor flow distortion and an almost completed experimental rig to verify the concepts.

W74-70053 **501-04-03**
Langley Research Center, Langley Station, Va.
BASIC PROPULSION RESEARCH
R. E. Bower 703-827-3285

Research investigations to develop aerothermodynamic concepts for scramjet engines for vehicle applications are underway. The research program includes an active inlet design and testing program for flight Mach numbers up to 10 with inlets which rely on complex compression surfaces or three-dimensional contours to achieve rapid compression and integration with the aircraft surface. An analytical and experimental research program on supersonic combustion and mixing is also included which involves the use of a combustion heater for simulating the conditions at the combustor entrance corresponding to flight Mach numbers from 3 to 9. Investigations of combustion, hydrogen fuel injection, mixing, and heat transfer in both 2-dimensional and axisymmetric flow fields for both wall and stream injection will be conducted. Some specific tasks in this program will be conducted by contract. Further development and performance evaluation using complete subscale engine models with hydrogen combustion will be done under Mach 7 flight conditions in the Langley 4-foot arc tunnel. This research is focused toward an experimental scramjet engine concept for application to a Hypersonic Research Airplane (HRA).

W74-70054 **501-24-01**
Lewis Research Center, Cleveland, Ohio.
NOISE TECHNOLOGY
E. W. Conrad 216-433-4000
(501-24-18; 501-04-01)

Research is performed on fan, core, and combustor noise and its suppression. Engine noise testing will be conducted with CTOL MK I Quiet Engine C incorporating open and nominal core nozzles, wing shielding, sonic inlets, and a core suppressor. Fan noise research will be conducted in the six-foot fan acoustic test rig and the 20-inch model rig in W-2. Several acoustic parameters (such as the correlation of aerodynamic pressure fluctuations with noise, reduced fluctuating stator lift, and reduced rotor-stator interaction), the noise effects of several aerodynamic design principles, and noise suppression characteristics will be evaluated. Jet source noise research will be conducted to determine combustor power spectra and far field directivity. The contribution of combustor noise to the far field will be investigated. Methods of suppressing core noise will be examined. Internal scrubbing and impingement noise and wing shielding will be evaluated. New ideas for noise generation, reduction, suppression, and measurement will be investigated. Sonic and hybrid inlets will be tested to obtain large noise reductions with minimum losses and installation penalties.

W74-70055 **501-24-01**
Langley Research Center, Langley Station, Va.
NOISE TECHNOLOGY
George W. Brooks 703-827-2042
(501-04-01)

The objective of this work is to develop and to verify an integrated program for predicting the acoustical performance of realistic configurations of jet engine inlet and exhaust ducts. A broad range of both analytical and experimental studies is required. This includes precision measurements and calculations of the sound fields inside finite ducts with airflow, with varying cross sectional areas, and with and without acoustical treatment materials. Particular attention will be directed to the very significant wave reflections at terminations, blockages, area changes, and impedance variations. Also included are studies of model scaling, test techniques including spinning mode synthesizer applications and the evaluation of the acoustical performance of duct liner materials at ambient and elevated temperatures. Results of in-house analytical duct propagation and radiation studies, complementary precision acoustic measurements in the ANRL test duct, as well as those of the supporting contract and grant study programs will be inputs to the development of a computer oriented program for predicting the acoustic performance and of engine flow ducts. The evaluation of the aerodynamic and acoustic performance of a family of sonic choked inlet configurations will

be completed in the Anechoic Noise Facility on the 12 in. diameter research compressor.

W74-70056 **501-24-01**
Flight Research Center, Edwards, Calif.
NOISE TECHNOLOGY
T. W. Putnam 805-258-3311

The technical objective is to investigate by means of full-scale flight and ground tests the noise generated by various aircraft, propulsive lift systems and propulsion systems. The various noise sources are to be identified, and in addition, the effects of shielding ground proximity and atmospheric conditions on the noise spectra received at a given position relative to the noise source will be determined. The noise of various aircraft for static conditions, during takeoffs, landings, and flybys will be measured at ground stations. An acoustically suppressed CF700 turbofan engine installed on an outdoor test stand will be used to investigate ground reflection effects, noise propagation losses, and the noise of geometrically different nozzles. An F-111B wing and a large flat plate will be used in conjunction with the CF700 engine to investigate various facets of propulsive lift noise.

W74-70057 **502-24-02**
Lewis Research Center, Cleveland, Ohio.
POLLUTION TECHNOLOGY
Richard A. Rudey 216-433-6160

Various techniques for reducing pollutant emissions will be investigated in full-scale primary combustors, various combustor segment rigs and in basic flame tube-type rigs. Techniques that will be explored for reducing nitric oxide emissions will include reduced reaction zone dwell-time, prevaporization of fuel, and premixing of fuel and air prior to combustion. Improved fuel atomization and primary zone fuel-air ratio optimization will be investigated for reducing carbon monoxide and unburned hydrocarbon emission. Extensive tests will be required in order to evolve combustor configurations which combine low pollutant engine characteristics with acceptable levels of other required combustor performance characteristics. The contract effort to identify odorant compounds will be extended and samples for study and identification will be sent to the contractor. The contract effort on combustor modelling will be continued. A contract effort will be started to examine new techniques of non-invasive analysis of exhaust gas constituents.

W74-70058 **501-24-03**
Lewis Research Center, Cleveland, Ohio.
CONTROLS TECHNOLOGY
A. S. Boksenbom 216-433-6480

The objective of this program is to develop and apply methods of dynamic analysis and control theory and concepts to the problems of airbreathing propulsion systems. Analyses and simulations of the dynamic characteristics of these systems will be developed. Control theories and concepts will be developed and applied to achieve improved performance and operation of the system. Special control hardware, such as servos, instruments, and actuators, will be developed as required. Experiments with components and complete systems will be performed to validate the methods and concepts developed for propulsion system control.

W74-70059 **501-24-05**
Ames Research Center, Moffett Field, Calif.
INLET TECHNOLOGY
H. M. Drake 415-965-5851
(501-04-03)

The objective of this research is to provide information needed in the design and operation of efficient air induction systems for supersonic aircraft. The specific areas receiving attention are: (1) a general understanding of basic flow problems encountered (flow fields at inlet entrance, boundary layer growth, interaction with shocks, separation, bleed, etc.) and derivation of mathematical design procedures; (2) more detailed studies of two general classes of inlets, two-dimensional and axisymmetrics; (3) continuous up-dating of available computer programs derived to aid in inlet design, and (4) flow distortion and fluctuations at the compressor face. The research studies are both analytical and experimental, and involve in-house, grant, and contract efforts.

W74-70060 **501-24-05**
Lewis Research Center, Cleveland, Ohio.
INLET TECHNOLOGY
M. A. Beheim 216-433-4000

Basic inlet technology will be developed to improve the methods for design of supersonic inlets. These methods include prediction of their steady-state and dynamic performance and compatibility with the airframe and engine. Inlet operating conditions from subsonic cruise through transonic acceleration to supersonic cruise Mach numbers will be covered. These methods will include a comprehensive set of computer programs to analyze the viscous and inviscid inlet flows and empirical data correlations from a matrix of supersonic cruise and dash inlets operating in both isolated and installed environments. Methods will be developed to evaluate such 'barrier' problems as inlet-engine compatibility, inlet-airframe compatibility and angle-of-attack tolerance. Effects of scale and flight conditions will be evaluated. Experimental programs will take place in 10x10, 8x6 and on the F-106 aircraft. Computer programs will be developed in-house and on contract and analysis will be compared with experimental results.

W74-70061 **501-24-06**
Lewis Research Center, Cleveland, Ohio.
NOZZLES AND INTEGRATION TECHNOLOGY
M. A. Beheim 216-433-4000

The objective is to develop the technology required for the design of nozzles and integration of the propulsion system with the airframe for future subsonic and supersonic cruise and dash aircraft. Candidate nozzles are tested quiescently in SW-21 and isolated in 8x6 SWT to compare their basic performance. A set of analytical computer programs is being developed to analyze and design nozzle internal and external flow. Experimental results are compared with theory to determine application of analysis and additional requirements. Effects of propulsion system integration will be studied using powered engine simulators in 8x6 SWT models so that inlet and exhaust flows are properly simulated. Large scale nozzle flight tests are made at transonic speeds with nacelles under the wing of an F-106 aircraft. This gives comparisons to study wind tunnel to flight effects and Reynolds number effects. The F-106 is also used to obtain flyby noise measurements on standard and noise suppression nozzles. This evaluates the effect of external flow. Nozzle cooling will be investigated analytically and by testing cooled nozzle configurations behind an afterburning J85 engine.

W74-70062 **501-24-07**
Lewis Research Center, Cleveland, Ohio.
FAN AND COMPRESSOR TECHNOLOGY
M. J. Hartmann 216-433-6650

Approaches to reduce fan and compressor cost and weight, to improve performance, and to reduce noise generation will be investigated. Reductions in component cost and weight can be obtained by increasing stage pressure ratio, thus reducing the number of stages and blades required. Low noise requires optimization of blade shapes, row spacing, as well as rotational speed and aerodynamic loading. Light weight fan and compressor components must operate efficiently and without stall over a broad range of operating conditions even with severe inlet flow distortion. Areas to be studied: (1) Blade shapes designed to operate at high Mach number levels and produce high stage pressure ratio will be investigated. (2) Approaches to obtain good efficiency and flow range of stages with high aerodynamic loading will be investigated. (3) Casing treatment, variable geometry blading, transonic blading utilizing oblique shocks and other methods of increasing stall margin, and distortion tolerance, will be applied. (4) Promising concepts for improved performance developed in single stage studies will be incorporated into multistage compressors. (5) Analytical and fundamental flow studies will be conducted to determine methods of extending compressor performance. (6) Advanced CTOL engine type fan will be tested.

W74-70063 **501-24-08**
Lewis Research Center, Cleveland, Ohio.
COMBUSTOR TECHNOLOGY
Richard A. Rudey 216-433-6160
(501-24-02; 501-24-18; 501-24-20)

Primary combustor research will establish the technology necessary for combustors having high performance and good durability at operating conditions typical of advanced commercial and military aircraft. Two different types of combustors are being investigated: a double-annular ram-induction combustor and the swirl-can modular combustor. Extensive tests are needed to assess the overall merit of each design. Several varieties of small (less than or equals 10 lbs/sec flow rate) reverse flow and axial flow type combustors will be designed and tested for performance and emission evaluations. A reheat burner program will be aimed primarily at the mixed-flow engine having a high temperature core exhaust stream. A variety of reheat burner concepts will be investigated and will evaluate fuel prevaporization and fuel-air premixing. Research will also be conducted on liner film-cooling; jet penetration and mixing, modified swirl-can modules, and high Mach number diffuser designs.

W74-70064 **501-24-09**
Lewis Research Center, Cleveland, Ohio.
TURBINE TECHNOLOGY
D. Poferl 216-433-6594
(501-21-31; 501-38-13)

The turbine program includes research on turbine aerodynamics, turbine cooling, and turbine life. Each of these areas are interrelated, and it is not practical to conduct research in one area without considering how the other areas will be affected. Advanced cooling schemes for very high gas temperature operation will require increased use of film cooling. The effects of this and other types of cooling air discharge are being investigated from the standpoints of heat transfer, aerodynamics, and blade life. Heat transfer, fluid flow, aerodynamics, and life investigations are underway for a variety of convection and film configurations for turbine sizes ranging from those for helicopter engines to high spool turbines for turbofan engines. Fundamental heat transfer investigations on film cooling are also continuing. Turbine cooling problems become much more severe at the very high heat fluxes that are encountered with turbine inlet temperatures in excess of 3000 F, and high gas pressures encountered with compressor pressure ratios in the range from 30 to 40. Design and fabrication of a turbine rig to investigate the aerodynamic, heat transfer, and life problems encountered with these high temperature, high pressure turbines is being accomplished using Coff funds. In addition, investigations are being made on multistage turbines with work factors from 3 to 5 for application to high bypass ratio lift or cruise engines.

W74-70065 **501-24-10**
Lewis Research Center, Cleveland, Ohio.
SUBSIDIARY MECHANICAL COMPONENTS
W. J. Anderson 216-433-4000
(502-01-07; 502-31-51)

Basic materials, development, design theory, analysis, and experimentation will be performed for extreme conditions with lubricants, lubrication systems, component materials and component designs for bearings and seals of advanced aircraft turbine engines to achieve efficient performance, reliability and extended life. Materials, fabrication techniques, designs, and lubrication techniques for gearing will be developed. Analytic techniques for balancing, determining, and controlling the dynamic behavior of shafts and rotors will be developed and corroborated experimentally to provide better design tools for high speed turbomachinery, shafting and transmissions.

W74-70066 **501-24-18**
Lewis Research Center, Cleveland, Ohio.
CLEAN COMBUSTOR TECHNOLOGY
Richard A. Rudey 216-433-6160
(743-34-21; 501-24-01)

A three-phase program was initiated to generate and demonstrate the technology required to develop advanced CTOL, aircraft engines with lower exhaust emission than is possible using current technology. The effort is primarily aimed at advanced commercial engines with compressor pressure ratios of 20 to 35 but will also consider military engine requirements. Primary emphasis will be placed on reducing nitric oxide emissions but reductions in unburned hydrocarbons, carbon monoxide, smoke, and particulates will also be sought. These reductions in pollutant emissions will be accomplished with minimum and acceptable sacrifices in other normal combustion performance requirements. The three phases will consist of initial screening of candidate configurations, (e.g., NASA, LeRC swirl-can combustor), experimental testing of best candidates, and an actual demonstration of the best design(s) in a modern high pressure ratio engine. This effort is a change in scope of an existing activity started in FY-1972 under RTOP 132-86-02. A change in scope for FY-73 is also planned. This consists of adding two supersonic cruise pollution technology addendum (RTOP 743-34-21) to the existing contracts.

W74-70067 **501-24-04**
Lewis Research Center, Cleveland, Ohio.
ENGINE TECHNOLOGY
J. H. Povolny 216-433-6624
(501-24-05; 501-24-08)

The objective is to develop the technology relative to turbine engine systems required for future subsonic and supersonic aircraft. Particular emphasis will be placed on seeking an understanding and solution of the dynamic interaction problems associated with flight systems. The latest turbojet and turbofan engines designed for both subsonic and supersonic cruise and supersonic dash applications will be used in the investigations. Exploratory and performance evaluations will be made of systems applicable to both civil and military airplanes currently being designed or developed. This effort is primarily concerned with the effects of inlet produced environment on the engine and the interactions of the various engine components. It is closely related to the inlet, inlet control, and inlet engine dynamics research described in RTOP 501-24-05.

W74-70068 **501-24-11**
Lewis Research Center, Cleveland, Ohio.
VTOL TECHNOLOGY
H. E. Rohlik 216-433-6131

The National Aeronautics and Space Administration is engaged in a program directed at the investigation of commercial and military VTOL aircraft employing low-downwash lift-propulsion systems. These systems include lift and lift/cruise fan engines and wing ejectors. Responsibility for VTOL airframe and aircraft studies is at Ames and is covered under another RTOP. The propulsion needs of the program are the responsibility of Lewis Research Center and include (1) establishing a technology base for lift propulsion components and systems, and (2) providing propulsion support to Ames for their aircraft studies as required. The technology program is directed at the investigation of problems associated with the engine and system components, integration of the components, installation effects, and noise generation.

W74-70069 **501-24-12**
Lewis Research Center, Cleveland, Ohio.
STOL TECHNOLOGY
Raymond J. Rulis 216-433-6651
(765-69-01)

The objective of this RTOP is to develop the propulsion technology required to support the development of a viable short-haul aircraft system. Major program elements include: (1) evaluation of high bypass fans for aerodynamic performance and noise (2) determination of installation effects on high bypass fan engines at low and high flight speeds (3) evaluation and development of lightweight composite fan blades (4) development and optimization of active and passive acoustic suppression techniques for fan jet engines, (5) evaluation and development of engine exhaust configurations for EBF powered lift systems, and (6) evaluation of a large scale optimized augmentor wing jet flap.

W74-70070 **501-24-14**
Lewis Research Center, Cleveland, Ohio.

LOW COST SMALL ENGINE TECHNOLOGY
Richard A. Rudey 216-433-6684
(501-24-14; 501-24-07; 501-24-08; 501-24-03)

An effort is being made to establish a general base of low-cost engine technology which could be directly applied to turbojet and turbofan engines in the 500 to 1000 pound thrust range. Such engines would be suitable for application to a wide range of non-recoverable missiles and drones and to general aviation aircraft where in both cases broader use of gas turbine engines is currently inhibited by their cost. Contribution to small gas turbine engine cost reduction technology is being made by simplification of the engine configurations, reduction in the size and the number of stages required, and use of low-cost materials. In addition, use of novel construction and fabrication techniques for axial flow compressor and turbines is being investigated. The feasibility of these low cost approaches is being demonstrated by the fabrication and testing of several variations of an expendable engine with a goal of 650 to 750 pounds of thrust for a potential ordnance use.

W74-70071 **501-24-15**
Lewis Research Center, Cleveland, Ohio.
HIGH PERFORMANCE SMALL ENGINE TECHNOLOGY
H. E. Rohlik 216-433-6131
(501-24-10; 501-24-08)

The objective of the program under this RTOP is to investigate problems associated with achieving high performance in advanced small gas turbine engines for such applications as small aircraft, helicopters, APU's and automotive use. As the size of these engines is reduced, it becomes increasingly difficult to achieve the aerodynamic and thermodynamic performance of the associated components while maintaining the required simplicity and ruggedness. Programs underway include the investigation of advanced small centrifugal and mixed flow compressors, cooled axial- and radial-inflow turbines, combustors, as well as advanced bearings and seals required for the high rpm's encountered in these applications.

W74-70072 **501-24-16**
Langley Research Center, Langley Station, Va.
HYPERSONIC RESEARCH ENGINE
R. E. Bower 703-827-3675

A practical, high-performance, Mach 3-8 liquid hydrogen ramjet engine is described. A full-scale, hydrogen-cooled, structures assembly model (SAM) and a full-scale, water-cooled aerothermodynamic integration model (AIM) of the HRE was built for measuring the aerothermodynamic performance from Mach 5 to 7. The engine structures thermal performance and low cycle fatigue characteristics were evaluated during Mach 7 testing conducted in the 8-foot high temperature structures tunnel. The objective is to advance and crystallize the technology of hypersonic air breathing propulsion systems and to evaluate the requirements for future research. The superior fuel economy of air breathing propulsion requires that such systems be reexamined in light of current technology for application to any new hypersonic atmospheric flight mission.

W74-70073 **501-24-16**
Lewis Research Center, Cleveland, Ohio.
HYPERSONIC PROPULSION TECHNOLOGY
E. A. Lezberg 216-433-6158

Engine testing of the HRE, Aerothermodynamic Integration Model will be conducted at the Plum Brook, HTF over a Mach number range of 5-7 to provide information on component interactions, ignition, combustion mode transition and performance. Facility unstart problems will be resolved to allow engine operation at an equivalence ratio of one, by modifications to the facility shroud and diffuser entrance cone angle approaching a closed tunnel configuration.

W74-70074 **501-24-11**
Ames Research Center, Moffett Field, Calif.
VTOL TECHNOLOGY
Bradford H. Wick 415-965-5567
(760-62-01)

This RTOP covers acoustic and performance research on lift fan propulsion systems. Lift fan propulsion systems require special consideration because of the desirability of limiting depth and weight which restricts acoustic treatment. In addition, the fans operate in severe distortion which affects performance and increases noise. For the former difficulty, detailed knowledge of noise sources in lift fan turbomachinery are required. For the latter, detailed integration studies are required. The proposed program attacks these problems. Studies with a statorless fan will be continued to provide data on a lift fan free of rotor-stator interaction noise, with possibly improved performance, and provide valuable data on rotor alone noise. Past studies have shown advantages to serrations for rotors and on NASA quiet fan 'B. Further cascade studies have shown an advantage to serrations for transonic cascades. Serrations will be studies on the statorless fan, and on a fan that has been the subject of prior research on noise and performance. Analytical studies of machinery noise sources of a single stage fan will be continued. An experimental investigation will be initiated of the effects of tip turbine leakage on noise (LF 336 fan). Research will be conducted with inlet stators to reduce inflow distortion and limit the increase in noise with crossflow. Subsequently, the results of these and other studies will be incorporated into a study of an advanced fan. Design, fabrication, and testing of the advanced fan will follow.

W74-70075 **501-06-01**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
COMPUTATIONAL AERODYNAMICS
John W. Lucas 213-354-4530

The object of this RTOP is to develop a new theory of differential systems, and to apply it to achieving a systematic understanding of selected important equations of continuum mechanics. The methods being developed are especially applicable to coupled sets of nonlinear ordinary and partial differential equations, where results previously have been found by ad hoc methods. Examples are (1) invariance transformations, (2) general similarity solutions, (3) characteristics, (4) integral conservation theorems, (5) functional variable transformations and discovery of superposition principles, and (6) variational principles. Of these, (3), (4) and (6) are of direct applicability in writing programs for numerical computation. The method is based on the modern calculus of exterior differential forms, and is especially appropriate for nonlinear equations such as occur in describing aerodynamic flows. The systematic structure of the theory also allows the use of computer symbolic analysis. In past joint work at JPL and IIT, a unique set of programs was developed for noncommutative algebraic manipulation of differential forms. These are available for application of the abstract general theory to specific equations of interest, for example, in the derivation of the most general similarity solutions. The most recent progress under this task has been in application to coupled sets of ordinary differential equations, in showing how Hamiltonian structures may always be found for these. Work is in progress in applying the theory to the systematic discovery of variational principles for nonlinear flows. These are used in relaxation type computer calculations, and have previously been discovered only by ad hoc methods.

W74-70076 **501-06-01**
Ames Research Center, Moffett Field, Calif.
COMPUTATIONAL AERODYNAMICS
Leonard Roberts 415-965-5066
(401-06-05; 501-06-08)

The objectives are to develop and apply analytical and numerical procedures which can be used reliably, accurately, and efficiently for the study of complex aerodynamic flow fields at subsonic, transonic and supersonic flight speeds using serial and parallel processing computers. The procedures will apply to two- and three-dimensional bodies and configurations and will include consideration of inviscid flows, viscous effects and propagation of sound through nonhomogeneous and/or stratified media. Flow field studies in the subsonic, transonic, and supersonic speed regime will continue covering inviscid and viscous laminar and turbulent flows with and without separation using finite difference, relaxation technique, and integral method solutions. Propagation of sound through nonhomogeneous fluids in motion is being studied numerically using discrete Fourier

methods and non-linear method of characteristics. The Ames Finite-Element Wing-Body Aerodynamics Computer Program will be modified to incorporate multiple bodies and vertical surfaces. Additional emphasis will be given to the subsonic speed regime, particularly in applying numerical analysis techniques to three-dimensional flows occurring on blown flaps, augmentor wings, multielement wings and other high-lift configurations.

W74-70077 **501-06-01**
Langley Research Center, Langley Station, Va.
COMPUTATIONAL AERODYNAMICS
P. J. Bobbitt 703-827-3561

The technical objectives are to develop and apply analytical and numerical procedures which can be used reliably, accurately, and efficiently for the study of complex aerodynamic flow fields throughout the range of flight speeds by advanced high speed computers. The procedures are to apply to two- and three-dimensional bodies and configurations and to account, in special cases, for viscosity at least to the extent of coupling boundary layer displacement and separation effects with the inviscid flow field. Improved methods for calculating turbulent boundary layer flows, jet/exhaust flows, and for predicting the effects of shock-boundary layer interaction are being developed. Analytical and numerical procedures will be developed for the prediction of pressure distributions, aerodynamic characteristics, flow fields, and heat transfer for inviscid and coupled inviscid-viscous flows with attached boundary layers, detached lee side flows with vortex formation, and other interactions. Both linear and nonlinear flow equations will be applied as appropriate. Mathematical techniques required typically depend on the problem; however, finite-element, finite-difference relaxation, time-asymptotic, characteristics, and integral methods are the most commonly used for solving nonlinear problems. Linear problems will generally be solved by the distribution of various types of singularities whose strengths are determined by the solution of a matrix equation.

W74-70078 **501-06-02**
Ames Research Center, Moffett Field, Calif.
DEVELOPMENT OF COMPUTATIONAL AERONAUTICAL CODES FOR ILLIAC
Glen Goodwin 415-965-5065
(501-06-01; 501-06-03)

The overall objective is to develop efficient and reliable computer programs that will solve fluid dynamics problems accurately on the Illiac and serial computers. A wide range of flow fields is to be simulated from low subsonic to hypersonic speeds for steady and unsteady, inviscid and viscous flow over two- and three-dimensional configurations including wings and wing-body combinations. New numerical methods are to be developed, especially ones that are suited for parallel processing. A new parallel processing program language, CFD code, will be used to write programs for execution on the Illiac, and with the use of newly developed translators, a FORTRAN program will be produced for testing or simulating the Illiac programs on serial computers. The specific objectives are the solution of inviscid transonic flow around wings and wing-body configurations with area ruling, very thick wings and wing-body combinations, and lifting airfoils in unsteady flight for flutter and buffet studies; and viscous flows including vortices, separation, flow in a corner, impingement of a shock wave on a wing leading edge, and shock-wave boundary layer interactions. The nature and effects of turbulence will also be studied for the viscous flows.

W74-70079 **501-06-03**
Ames Research Center, Moffett Field, Calif.
PHYSICAL MODELING AND VERIFICATION OF ILLIAC COMPUTER CODES
Glen Goodwin 415-965-5065
(501-06-02)

The objectives are to perform fundamental experiments specifically designed to verify two- and three-dimensional Illiac codes, and to provide the necessary modeling of the physics of turbulent flows to be included in these codes. The Reynolds number domain will extend from the relatively low values of conventional wind tunnels up to the practical range of existing and future aircraft for the transonic and supersonic speed regimes. Some of the flows to be studied will emphasize pressure gradients, separation, and shock interaction regions. Initial objectives are to perform experiments relevant to the development and verification of two advanced computer codes currently being developed at Ames for the numerical simulation of the transonic flows about airfoils. A two-dimensional viscous code will be evaluated by comparing surface pressures obtained from numerically simulated flows with experimental values for unswept wings in supercritical flow regimes including cases where shock-induced boundary layer separation occurs. Second, a three-dimensional inviscid code, capable of adequately treating highly sweptback local shock waves will be evaluated by comparing surface pressures with measurements on highly swept airfoils at sufficiently high Reynolds number to preclude occurrence of dominant viscous effects. A study will be conducted at high subsonic and moderately supersonic speeds of the turbulent boundary layer with pressure gradient and/or separation including the effects of impinging normal or oblique shock waves. The measurements will include surface skin friction and time-dependent quantities within the turbulent layer for length Reynolds numbers up to 300 million and will provide the turbulent shear stress and kinetic-energy turbulence models needed for transonic viscous computer code development.

W74-70080 **501-06-04**
Langley Research Center, Langley Station, Va.
VORTEX LIFT
R. E. Bower 703-827-3285

The technical objectives are: (1) to provide an improved understanding of the formation, characteristics, and aerodynamic effects of the various vortex flows that are developed in conjunction with flow separation at or near the leading edges or tip edges of wings of arbitrary planforms and camber surfaces; and (2) to develop analytical design and analysis methods which accurately account for these flows. Primary emphasis will be placed on those vortex flows which involve sizable vortex lift increments, and methods of controlling, augmenting, and exploiting this lift source will be studied. Both subsonic and supersonic speeds will be considered and implications with regard to the aerodynamic characteristics of slender supersonic cruise vehicles and maneuvering aircraft and missiles will be examined. Both in-house, contract, and grant research will be utilized to accomplish the objectives. The in-house effort will include experimental studies using various wind tunnel facilities and analytical studies based on application of finite element techniques and on the application of the edge suction analogy. Where desirable, the program will be augmented by means of contracts and grants.

W74-70081 **501-06-05**
Langley Research Center, Langley Station, Va.
AIRFOIL AERODYNAMICS
R. E. Bower 703-827-2210

The objectives are to provide: (1) improved airfoils and multielement high lift airfoils for advanced subsonic aircraft and transonic executive and commercial transports; and (2) improved blade element airfoils for new performance capability for advanced military and commercial transport rotary wing aircraft. Improvements are sought in the areas of basic aerodynamic performance, high lift and controls performance, and stall behavior. The work will be an intermix of both experiment and applied theory and will provide: (1) measurements of aerodynamic characteristics for selected configurations; (2) upgraded predictive aerodynamic analysis; (3) generation of airfoil design methodology for both subcritical and supercritical aerodynamic regimes; and (4) stimulation of new and unique design concepts, theoretical methods, and experimental techniques. Examples include new supercritical airfoils, general aviation airfoils, leading and trailing edge high lift devices; and new rotorcraft blade sections. The research identified herein constitutes: (1) grouping of several isolated elements of airfoil research, some of which are associated with a particular application, (2) evaluation of these elements in relation to long range objectives, and (3) identification of new or additional goal-oriented investigations.

W74-70082 **501-06-05**
Flight Research Center, Edwards, Calif.
AIRFOIL AND CONFIGURATION AERODYNAMICS
E. J. Saltzman 805-258-3311

The technical objectives are: (1) to improve the ability to predict the aerodynamic efficiency (or performance) of vehicles which move through the atmosphere: and (2) to define how the efficiency of airfoils or complete vehicles is influenced by geometry, Reynolds number, surface roughness and texture, and free stream and local flow conditions. In addition, experimental research on turbulent boundary layer phenomena will be conducted including the effects of compressibility, pressure gradient, heat transfer and surface roughness, and the interaction of turbulent boundary layers and shock waves and separated flow phenomena. Overall and incremental drag of powered and coasting vehicles will be defined by the accelerometer and/or dynamic analysis methods augmented by the stabilized glide and rate of sink methods. Airfoil performance will be defined by conventional pressure distribution techniques, boundary layer rakes, and trailing wake probes, augmented by flow visualization where required. Pressure distribution techniques will also be used in assessing boattail and base drag, and in studying means of reducing these components of drag. Turbulent boundary layer studies will utilize rakes, traversing probe devices and force balances augmented by hot wire and hot film techniques where applicable. The results of these experiments will be correlated with ground facility and theoretical predictions and reported through the normal NASA reporting mediums.

W74-70083 **501-06-05**
Ames Research Center, Moffett Field, Calif.
AIRFOIL AND CONFIGURATION AERODYNAMICS
Leonard Roberts 415-965-5066
(501-06-01; 501-06-07; 501-06-08)

This RTOP covers experimental investigations on airfoils, components, and configurations for advanced subsonic, transonic, and supersonic aircraft. The objectives of this research are: to provide basic aerodynamic information on advanced and/or improved airfoils; to improve the basic understanding of complicated flows, such as flow separation on multielement high-lift wing configurations; and to determine the potential configuration advantages of the antisymmetric wing concept for use on various configurations. The airfoil data will be for use on both fixed and rotary-wing aircraft. This work will be primarily experimental and will be conducted in-house. Complementary theoretical investigations are covered in RTOP 501-06-01.

W74-70084 **501-06-06**
Ames Research Center, Moffett Field, Calif.
NONSTEADY AERODYNAMICS
H. M. Drake 415-965-5851

The principal objectives of this research are to obtain an improved understanding and definition of the unsteady aerodynamic pressures and forces associated with aircraft buffet as affected by aerodynamic and geometric parameters; to obtain an improved understanding of the reaction or coupling of the aircraft structure to the unsteady aerodynamics; and to develop methods of predicting buffet and wing rock. Wind tunnel tests, verified by selective flight tests, will be conducted to obtain unsteady loads, pressures and model response characteristics for conditions from buffet onset through maximum buffet and wing rock onset. Additional wind tunnel parametric studies will be made to assess various approaches toward alleviation of buffet and wing rock.

W74-70085 **501-06-08**
Langley Researvh Center, Langley Station, Va.
TURBULENT BOUNDARY LAYERS
R. E. Bower 703-827-3406
(501-06-03)

This work is to improve the ability to predict the behavior of turbulent boundary layers and turbulent free mixing flows for aeronautical design purposes. Basic theoretical and experimental research on turbulent boundary layers and free mixing flows include effects of compressibility, pressure gradients, mass and heat transfer, and three-dimensional flow. Studies include interaction of turbulent boundary layers and shock waves, the development of physical models of turbulent shear, structure of separated turbulent flows, and an examination of means for reducing turbulent skin friction drag in subsonic and supersonic flows. A coordinated theoretical and experimental program will be conducted in which theoretical turbulence models are postulated based on the physics of the situation, with inputs from carefully conducted experiments which measure surface shear and heat transfer and detailed structure of turbulent flows obtained by standard techniques and by means of hot wires, lasers, and other advanced measurement techniques. Detailed data and turbulent models are used to develop and verify several large numerical codes including computational methods for three-dimensional boundary layers, three-dimensional mixing and vortex flows, and separated flows.

W74-70086 **501-06-08**
Ames Research Center, Moffett Field, Calif.
TURBULENT BOUNDARY LAYERS
H. M. Drake 415-965-5851
(501-06-01)

This continuing effort is to conduct analytical and experimental investigation of turbulent boundary layer flows under conditions where present understanding of such flows is inadequate and must be improved. These conditions, for which the flow may be separated or attached, include: (1) flows over highly curved surfaces providing severe adverse pressure gradients (with and without bleed or mass injection); (2) flows in the immediate region of, and downstream of, shock-wave boundary layer interaction; and (3) flows subject to variation of edge entropy and vorticity. In addition, this effort is concerned with development of advanced computer programs, for predicting flows for both internal and external configurations.

W74-70087 **501-06-10**
Langley Research Center, Langley Station, Va.
INSTRUMENTATION RESEARCH
R. E. Bower 703-827-3483
(502-03-53)

This effort will develop instrumentation technology to improve measurement techniques to satisfy present and fqture aeronautical testing requirements. The work is predominately an in-house effort with emphasis placed on research where successful results will provide measurement technology broadly applicable to aeronautical programs. Technology developed under this RTOP will be coordinated with more focused instrument development in other programs. Research to be pursued includes improvements in size and dynamic response of pressure transducers, gas velocity measurements, gas analysis instrumentation, cryogenic temperature sensing techiques, aerodynamic load measurements, and automatic facility test control techniques. These research tasks will be continually aligned with present and projected aeronautical program measurement requirements.

W74-70088 **501-06-10**
Ames Research Center, Moffett Field, Calif.
FLOW MEASUREMENT TECHNIQUES
H. M. Drake 415-965-5851
(501-06-08)

Based upon the successful Ames small-scale pilot development of a laser velocimeter system for obtaining mean velocities, turbulence intensities, and Reynolds stress components in both low and high speed flows, a large scale (8-watt) portable laser velocimeter system is to be developed for measuring local velocities in all of the large Ames test facilities. Measurements will continue to be made with the 4-watt laser velocimeter in the Ames 8 x 8 inch supersonic wind tunnel in the natural boundary layer on the tunnel wall and downstream of a shock-wave, boundary layer interaction, and compared with hot wire anemometer measurements. This effort will be coordinated with the analytical and experimental studies in the turbulent boundary layer task of RTOP 501-06-08.

W74-70089 **501-06-12**
Ames Research Center, Moffett Field, Calif.
WAKE VORTEX MINIMIZATION

Bradford H. Wick 415-965-5567
(501-38-13)

To obtain both short range and long range aerodynamic solutions to the aircraft operational hazard caused by aircraft trailing vortices, investigations will be made to determine: (1) The fundamental mechanisms involved in vortex generation and decay. (2) The components of vortex velocity and turbulence up to large distances behind a wing for various conditions of angle of attack, wing sweep, flap deflection, etc. (3) Vortex dissipation resulting from alternations in span loading, trailing devices and mass injection, etc. The approaches to be used are: (1) theoretical studies, and experimental investigations utilizing wind tunnels and water tunnels; (2) development of improved equipment and techniques for wind tunnel and water tunnel investigations, and (3) application of promising hazard alleviation to models of specific transport aircraft and their experimental evaluation.

W74-70090 **501-06-12**
Langley Research Center, Langley Station, Va.
WAKE VORTEX MINIMIZATION
R. E. Bower 703-827-3285

The objective is to investigate and determine aerodynamic changes required to reduce the hazard of aircraft trailing vortices and to optimize these changes to achieve their dissipative effects with minimum adverse penalties to the aircraft. Various methods of creating an instability or inducing a rapid dissipation of aircraft trailing vortices are to be investigated in model tests. The near-field effects of vortex dissipation devices and the performance decrement created by these devices are being evaluated in the Langley V/STOL tunnel. The David Taylor model basin is being modified to fly, in air, a large aircraft model along the 1,800 ft overhead carriage. This facility will be used to determine the far-field effects of vortex dissipation devices. Also, the far-field effects are to be evaluated under contract in a large water-towing tank. This facility is capable of providing model tests at nearly full-scale Reynolds numbers at scale distances 2- to 3-miles. In all of the test facilities, the effects of the candidate vortex dissipator techniques will be evaluated on the basis of a reduction in the imposed rolling moment on a following aircraft model. The same aircraft following model and vortex generator model will be used in order to make comparative measurements.

W74-70091 **501-06-13**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
AIRFRAME NOISE
John W. Lucas 213-354-4530

The objective of this RTOP is to identify and to seek to reduce the sources of noise produced by the external, i.e. non-propulsive, components of aircraft for speeds ranging up to transonic. The work is principally experimental and will be carried out in the JPL 20-inch wind tunnel and in a low-turbulence tunnel. The flow fields to be studied for noise generation are chosen to represent separated flows over wells and cavities, behind steeply-deflected control surfaces, behind bluff objects, and in the shock wave-boundary layer interaction zone for wings with transonic regions. The measurements are made by use of microphones and hotwire anemometers. Field measurements will be planned on the basis of wind tunnel results and techniques. As a by-product, the Reynolds stress in a transonic boundary layer will be measured.

W74-70092 **501-06-13**
Langley Research Center, Langley Station, Va.
AIRFRAME AERODYNAMIC NOISE
R. E. Bower 703-827-3285

Experimental and theoretical studies will be conducted to identify and reduce the noise of various components of the airframe and of the airframe as a whole. Analytical methods for predicting airframe noise will be developed. Small-scale models in quiet wind tunnels and large-scale (actual aircraft in some cases) models will be used in the full-scale tunnel to identify noise sources and explore methods of reducing this noise at its sources. Theoretical studies will be included to guide the experiments and to provide a base for the noise prediction techniques.

W74-70093 **501-06-13**
Ames Research Center, Moffett Field, Calif.
AIRFRAME AERODYNAMIC NOISE
Leonard Roberts 415-965-5066
(501-04-01)

Research is underway to obtain an understanding of the fundamental mechanisms of noise generation and propagation from airflow over the airframe of an aircraft in flight. The primary objective is to develop improved and/or new methods for prediction of airfoil/airframe generated noise and to investigate methods whereby such noise could be effectively reduced without undue design penalty. Noise sources to be investigated will include turbulent boundary layers over airframe surfaces, vortex system from lifting surfaces, flow separation due to cavities and bluff bodies (e.g. landing gear), and trailing edge flaps. Special diagnostic techniques will be developed to minimize extraneous noise such as wind tunnel background noise and microphone wind noise. Systematic large-scale tests can be conducted in the 40- by 80-foot wind tunnel to quantify and identify the source of the airframe noise. The experimental results will be used to verify the accuracy of the theoretical estimates. When prediction techniques are in hand, they will be used for the design of configuration changes which will reduce airframe noise. The reduction will be verified in a series of wind tunnel test on models of existing aircraft and representation of future aircraft. As a parallel effort, feasibility studies of other types of facilities for measuring airframe noise will be conducted to identify advantages of other facilities for specific tests.

W74-70094 **501-06-13**
Flight Research Center, Edwards, Calif.
AIRFRAME AERODYNAMIC NOISE
P. L. Lasagna 805-258-3311
(501-24-01)

The objective is to obtain an understanding of the fundamental mechanisms involved in the generation of noise from other than propulsive sources by the airflow over the airframe of an aircraft in flight, and to investigate methods whereby such noise could be effectively reduced without undue design penalties. In addition to theoretical studies, flight tests will be made using a series of airplanes to measure the ground noise of each airplane while descending along a landing approach path with the engines off. In so far as practical, the flight speed and configuration geometry of each airplane will be varied to ascertain the effects of flaps, slats, cavities, etc., on the noise spectrum and level. Initial tests were done with an AeroCommander and testing is now being continued with the JetStar. Later, it is planned to use an F-111 and other aircraft.

W74-70095 **501-06-07**
Langley Research Center, Langley Station, Va.
BOUNDARY LAYER STABILITY AND TRANSITION
R. E. Bower 703-827-3406

Research will be conducted to improve the understanding and prediction of boundary layer stability and transition, because of the importance of transition behavior on aerodynamic heating and its influence on thermal protection systems, on aircraft lift-drag ratios, on missile observables, and on vehicle dynamics. Emphasis will be on understanding the role of the fundamental factors that affect transition as measured in ground facilities and in flight, in order to improve the correlation of such measurements and to establish a base of information for design applications. Means will be investigated for the control of the wind tunnel environment to more closely simulate the conditions of flight. Using models of simple geometry, such as slender cones, the effects of the disturbance environment on transition as measured in wind tunnels and ballistic ranges will be identified and evaluated. Attention must be given to disturbances introduced by model surface and structure as well as the tunnel environment. Through boundary layer control and other disturbance suppression devices, a quiet supersonic tunnel which would suppress adverse environmental disturbances is to be developed. The program is primarily experimental but with close theoretical support and is directed toward understanding of fundamental processes.

W74-70096 **501-06-09**
Langley Research Center, Langley Station, Va.
TUNNEL AND SCALE EFFECTS ON TRANSONIC FLOW
R. E. Bower 703-827-3483
(760-64-01)

The objectives are to determine the wind tunnel and scale effects on flow characteristics at transonic speeds, including correlation between wind tunnel and flight. Research will include determination of model support interference, tunnel wall constraints, and flow quality. Studies and development of ground-based facility concepts to achieve the desired flow characteristics will be undertaken. Systematic studies will be made of scale effects on the transonic aerodynamic characteristics of wings, bodies, and complete configurations. Experimental pressure and flow field surveys will be made at the highest attainable Reynolds numbers. The following concepts of facility design will be studied analytically and experimentally at model scale to assess the most feasible facility approach: (1) injector-driven closed circuit tunnel of 2 meter size (200 psia stag); and (2) a cryogenically cooled facility for max Reynolds number at minimum dynamic pressure. Operation of a prototype model of a 3-D magnetic suspension and balance system will be undertaken. *The various facility studies will be supplemented by analytical* and experimental efforts to develop transonic test section designs for minimum wall boundary interference.

W74-70097 **501-06-09**
Ames Research Center, Moffett Field, Calif.
TUNNEL AND SCALE EFFECTS ON TRANSONIC FLOW
H. M. Drake 415-965-5851

The general objective is to develop improved transonic wind tunnel test techniques in order to ensure reliable correspondence between viscosity-dependent data obtained from scale-model tests and that from full-scale flight tests. Tunnel wall constraints, flow quality, and means for simulating higher Reynolds number flows through the use of dense gas mixtures will be investigated analytically and experimentally.

W74-70098 **501-26-01**
Flight Research Center, Edwards, Calif.
HANDLING QUALITIES - CRITERIA FOR HIGHLY AUGMENTED VEHICLES
H. A. Rediess 805-258-3311

The overall objective of this effort is to advance the fundamental knowledge of flight dynamics and to exploit this knowledge to develop methods of optimizing specific flight control or performance goals and to improve flight test analysis techniques. Analytical studies, computer simulations, and flight test investigations are being performed both in-house and under research contracts and grants to meet this objective. The range of command responses of augmented aerospace vehicles that optimizes the pilot-vehicle performance for specific missions or a specific task within a mission will be investigated. The main emphasis will be to investigate criteria for desired command responses that are meaningful to the systems designer and not needlessly restrictive as to the system concept employed. This activity will also study and document the relationship between the stability and control characteristics of airplanes in general and the pilot's assessments of the handling qualities, through the use of simulators (both fixed-based and airborne) and the actual airplanes. Effects of turbulence on the flying and ride qualities will be of major concern.

W74-70099 **501-26-02**
Ames Research Center, Moffett Field, Calif.
HANDLING QUALITIES - TURBULENCE/FLEXIBILITY EFFECTS
H. P. Klein 415-965-5094

Aircraft response to atmospheric turbulence is a prime factor in the design and operations of all aircraft. In order to study these phenomena, accurate models of the turbulence are needed. A non-Gaussian turbulence model has been developed and a computer program has been written for use on the Flight Simulator for Advanced Aircraft, and an in-flight program will be carried out to determine the span wise distribution of turbulence. An analytical/experimental program is planned to synthesize an optimum gust-alleviation system for light wing loading STOL aircraft. This work will incorporate turbulence models developed previously under grant studies by the University of Washington. The ride qualities and handling qualities of large, flexible aircraft are major factors affecting pilot-vehicle performance. Research is needed to: (1) refine currently available ride qualities criteria; (2) develop analytical pilot/vehicle system models which account for the effects of ride qualities on pilot control performance; (3) determine effects of improved flight director displays and turbulence penetration procedures for large civil transport operations in severe turbulence. Several piloted simulation studies will be carried out. Initial studies will use the Vertical Acceleration and Roll Device (VARD) to determine the effects of cockpit vibration at several selected levels and frequencies on pilot's assessment of ride qualities and on pilot performance. In a subsequent study on the VARD, the effects of ride qualities, associated with low-altitude high speed penetration missions of a large, flexible bomber aircraft, on pilot performance and opinion will be determined.

W74-70100 **501-26-04**
Langley Research Center, Langley Station, Va.
VEHICLE DYNAMICS - STALL/SPIN/HIGH ALPHA CHARACTERISTICS
R. E. Bower 703-827-3285

The broad objective is to expand fundamental knowledge of the stall/spin characteristics of aircraft, and to determine the effects of these characteristics in terms of piloting the aircraft. Specific objectives are: (1) to investigate the fundamental nature of stall/spin including the development of methods for theoretical analysis, (2) to investigate use of control systems for automatic spin prevention, (3) to determine aerodynamic characteristics at high angles of attack, and (4) to determine characteristics which produce a spin-resistant airplane. The methods of approach include wind-tunnel force tests, theoretical analysis, piloted simulator tests, and dynamic model tests.

W74-70101 **501-26-04**
Ames Research Center, Moffett Field, Calif.
VEHICLE DYNAMICS - STALL/SPIN/HIGH ALPHA CHARACTERISTICS
Leonard Roberts 415-965-5066

The primary emphasis in this program will be on the identification of aerodynamic characteristics leading to out-of-control aircraft motions brought about by flying at high angles of attack. Improvement of methods for predicting these characteristics and the application of these findings to the definition of new criteria for designing vehicles capable of performing controlled maneuvers over an expanded angle-of-attack envelope are also described. Investigations will be made of various experimental concepts for determining dynamic characteristics of aircraft at high angles of attack including tests leading to the design and construction of a large scale rotary apparatus to be used in the Ames Unitary and the 12 ft wind tunnels. Efforts will be made to synthesize approximate computational methods based upon experimental observations. Large-scale low-speed wind-tunnel investigations and flight simulator studies across the speed spectrum will be conducted to provide data on the cause and effect of asymmetrical forces occurring at high angles of attack. The use of conventional control systems and of unique devices for spin prevention in coping with these upsetting forces will be evaluated.

W74-70102 **501-26-05**
Langley Research Center, Langley Station, Va.
ADVANCED CONTROL APPLICATIONS
R. E. Bower 703-827-3285
(766-75-02; 742-73-01)

The objective is to develop a broad base of technology in advanced control systems. This makes available to the designer the ability to improve the performance of aircraft by reducing the size of stabilizing surfaces, by allowing a wider choice of configuration and wing loading, by avoiding undesirable flight regimes which might impose hazardous loads or loss of control, and by making the aircraft less sensitive to turbulence and gusts. The adoption of techniques allowing maximum utilization of these

principles in the early design stages of an aircraft are investigated. Analytical studies are conducted to investigate the application of several aspects of modern control theory to airplane dynamics and control systems synthesis. These studies include methods of decoupling the airplane responses to individual control inputs, the development of synthesis techniques for complex multivariable control systems which operate over a wide range of flight conditions, the application of adaptive control techniques, and the synthesis of gust-alleviation systems. Simulation studies are utilized to investigate the effect of promising systems on pilot opinion and handling qualities.

W74-70103 **501-26-06**
Flight Research Center, Edwards, Calif.
ADVANCED CONTROL APPLICATIONS - FLY-BY-WIRE EXPERIMENTS
C. R. Jarvis 805-258-3311
(766-75-01)

The overall objective of this joint effort with LaRC is to provide the technology necessary for the implementation of advanced reliable digital fly-by-wire systems in future aircraft. The program is to be carried out in accordance with the schedules and resources identified by the digital fly-by-wire project plan submitted in February 1973 and formally approved in March 1973. In Phase 1, currently underway, flight tests are being conducted on an F8C aircraft employing a single channel digital systems which was developed using Apollo hardware, to establish the feasibility of digital fly-by-wire systems. These tests will investigate handling qualities, aircraft response, design techniques, and filter and gain variations during low-speed and cruise flight. In Phase 2, through a cooperative effort with LaRC, a multichannel all digital system is to be developed and flight tested in the F8C aircraft. A dual channel system will be developed and flight tested initially, which will later be expanded to a three or four channel configuration. Provisions will be made to evaluate, in flight, advanced control laws being developed by LaRC in accordance with the project plan schedule.

W74-70104 **760-60-01**
Ames Research Center, Moffett Field, Calif.
GENERAL AVIATION - TECHNOLOGY
Leonard Roberts 415-965-5066

The objective is to provide advanced technology for general aviation that will permit the design of future aircraft that are safer and more productive. Advanced wing designs will be developed having improved low-speed control and stall characteristics combined with improved cruise drag and stability. Promising aircraft configurations will be studied which have practical inherent or artificial stall immunity. A reasonably inexpensive integrated digital avionic system for general aviation aircraft will be investigated. The system will be capable of interacting between the pilot, aircraft sensors, the ATC system, and the aircraft.

W74-70105 **760-60-01**
Langley Research Center, Langley Station, Va.
GENERAL AVIATION - AERODYNAMICS AND CRASHWORTHINESS
R. E. Bower 804-827-3285

The objectives for aerodynamics are: to study and document aircraft characteristics, operational factors, and human factors affecting flight safety; and to provide data for improvement of this level of safety through analysis, wind tunnel studies, and flight investigations of various means for improving the handling and flying qualities and for simplifying the piloting task from takeoff through landing. The objectives for crashworthiness are: to provide the technology necessary to permit the prediction and design of crashworthy light aircraft structures; to undertake analytical and experimental studies to define the basic mechanisms involved in crash behavior; to develop reliable analytical techniques for evaluating crashworthiness; and to apply and demonstrate the developed technology.

W74-70106 **760-60-05**
Flight Research Center, Edwards, Calif.
FLIGHT DYNAMICS - CONTROL AND DISPLAY
M. R. Barber 805-258-3311
(501-23-21)

The technical objectives are: (1) to identify and demonstrate the optimum levels of stability control and handling qualities for general aviation aircraft that can be achieved through the application of modern control technology; and (2) to define minimum system characteristics that permit realizing these levels. Flight and simulator studies will be continued in control display interactions. Degradation of system and component performance will be used in addition to mixing control modes between axis in order to define minimum aystem characteristics. Economical system mechanizations that provide these characteristics will be explored. Studies will be made of benefits, including direct lift/drag control devices in a flight path command mode of control.

W74-70107 **760-61-02**
Langley Research Center, Langley Station, Va.
POWERED-LIFT AERODYNAMIC PERFORMANCE
R. E. Bower 703-827-3285
(501-24-12)

The objective is to provide the technology required for improved performance and handling qualities of powered-lift aircraft configurations that are designed for low noise. Primary emphasis in FY 1974 will be placed on configurations with propulsion systems using the principle of attached flow on the upper surface to reduce noise. Theory, wind tunnels, static rigs, and simulators will be used to provide basic aerodynamic and handling qualities data through parametric ranges when appropriate. Design studies will be used to determine the problems and potential of integrating these results to minimize noise. A related technology refinement contract effort will be used to augment the in-house effort of this RTOP. This will bring industry capability in the areas of design and system integration into the total powered-lift research effort.

W74-70108 **760-61-02**
Ames Research Center, Moffett Field, Calif.
POWERED-LIFT (STOL/RTOL) AERODYNAMIC PERFORMANCE
Leonard Roberts 415-965-5066
(501-06-13)

This RTOP covers Ames on R/STOL aerodynamics and noise. The goal is to provide aerodynamically efficient, quiet, and mechanically simple powered lift systems that provide RTOL and STOL performance. Contracted and in-house studies have shown that the augmentor wing can meet noise goals and that the augmentor nozzles can also be used for cruise propulsion. These augmentors are yet to be proven at large scale, but this will be done in FY-1974. In addition, a combined theoretical and experimental program to improve augmentor performance and acoustics will be begun. Studies of quiet augmented jet flap thrust reversers will be included. Acoustics and performance of the USB concept will be studied in the 40 by 80-foot wind tunnel. This model will be comparable to the models of the other concepts that have already been studied. Fabrication of an RTOL model will begin in the last of FY-1974. This model will incorporate advanced high lift devices. Studies of an augmentor for cruise, started in late FY-1972, will continue.

W74-70109 **760-61-03**
Ames Research Center, Moffett Field, Calif.
STOL/RTOL FLIGHT DYNAMICS
Leonard Roberts 415-965-5066
(766-71-02)

Generalized analytical studies, ground based simulation, flight research will provide data for revision and extension of existing handling qualities criteria for application to STOL transport aircraft. Data will apply to the following critical areas: flight path, airspeed, and attitude control; landing flare in the presence of ground effect; and roll and yaw control for cross-wind operation. The program will be coordinated with the augmentor wing jet STOL, and OV-10A research aircraft programs. The latter aircraft will be utilized in a coordinated simulation flight program to study handling qualities problems related to flight path control, power management, and minimum speed selection. The AWJSRA flight program is covered by RTOP 766-71-02. Tentative certification criteria based on studies of representative STOL aircraft will be

developed in cooperative FAA/NASA piloted simulation studies on the flight simulator for advanced aircraft. These results will contribute to generalized criteria for all concepts. Development of procedures for demonstrating compliance to the criteria will also be undertaken.

W74-70110 **760-62-01**
Ames Research Center, Moffett Field, Calif.
VTOL AERODYNAMIC PERFORMANCE
Leonard Roberts 415-965-5066

This RTOP covers research on the aerodynamics, performance, stability, and control of promising jet-lift VTOL commercial and military transport configurations, including a better understanding of propulsion-aerodynamic interactions. Analytical methods for predicting these characteristics will be improved. Wind tunnel investigations of a large scale model of a lift-fan research aircraft both in and out of ground effect will continue. Large scale wind tunnel investigations of aircraft components will continue, as will wind tunnel research on the noise generated by lift-fan jet-lift VTOL aircraft at forward speed. Analytical studies to improve prediction methods will begin. A wind tunnel investigation of a large scale VTOL augmentor will be initiated. Theoretical and experimental studies of cruise performance of lift/cruise fan powered VTOL aircraft will continue.

W74-70111 **760-62-01**
Langley Research Center, Langley Station, Va.
VTOL AERODYNAMIC PERFORMANCE
R. E. Bower 703-827-3285

The basic research objective is to provide the technology required for improved performance, stability, and control of promising lift-fan or lift-jet VTOL configurations that would have application in civil and military transports as well as military fighter and attack aircraft. An additional objective of these investigations is to use experimental results to assist the development of more useful analytical methods for predicting the aerodynamic characteristics and gain a better understanding of propulsion-aerodynamic interactions. Limited fundamental studies will be continued in-house and by contract to develop, through theory and experiment, engineering design methods for optimizing the aerodynamics of lift-fan V/STOL aircraft. University grants will augment the in-house analytical work. A major emphasis will be placed on investigations of promising lift-fan transport configurations in the V/STOL tunnel. In addition, exploratory wind-tunnel research under this RTOP will also be concerned with a general study of a VTOL fighter-type configuration using the ejector augmented-lift principle or the deflected thrust concepts suitable for application in the Navy sea control concept.

W74-70112 **760-62-02**
National Aeronautics and Space Administration, Washington, D.C.
V/STOL FLIGHT DYNAMICS
R. W. May, Jr. 202-755-2405

Flight and ground-based simulation research is being carried out by Ames and Langley with V/STOL aircraft to study handling-qualities and terminal-area operation problems of such aircraft. As part of the overall investigation, the Navy X-22 tilt-duct, V/STOL airplane is being utilized in a program funded by the Navy, Air Force; FAA and NASA. The X-22 has a wider allowable descent envelope than most other VTOL aircraft and reduced cruise-to-approach crew workload requirements. These two significant factors of the X-22 make this aircraft particularly suitable for extending the terminal area operations research already performed to determine minimum airspace requirements and associated terminal area flight procedures for Instrument Flight Rule (IFR) operations.

W74-70113 **760-62-02**
Ames Research Center, Moffett Field, Calif.
VTOL FLIGHT DYNAMICS
Leonard Roberts 415-965-5066
(760-61-03; 760-63-05)

Design and certification criteria will be developed for satisfactory manual control of jet or fan lift VTOL aircraft. Two areas of primary concern are control of the aircraft for precise decelerating approaches to hover; and precision control in hover. Flight and simulation studies have indicated that hover vector management to control speed and position relative to the flight path is the primary problem to be solved to obtain satisfactory manual control during the IFR approach. Analysis and simulation, centered on a lift-fan research transport configuration, will be conducted to evaluate various techniques of automating control of the magnitude and direction of the thrust, and to develop improved concepts. Control systems for precise control of hovering aircraft will be considered for both commercial and military applications. Candidate systems for specific VTOL aircraft will be developed through analysis and simulation. In-flight verification and extension of results will be accomplished with the X-14B variable stability aircraft. The long range plan includes simulations and eventual in-flight verification to establish certification criteria for VTOL commercial aircraft.

W74-70114 **760-62-03**
Ames Research Center, Moffett Field, Calif.
HANDLING QUALITIES REQUIREMENTS FOR SHIP-BASED VTOL
Bradford H. Wick 415-965-5567
(760-62-01; 760-62-02)

Solutions will be sought to the special problems involved in manual control of the takeoff, approach, and landing of VTOL aircraft operating from the Navy Sea Control Ship (SCS) under severe weather conditions. The approach to these problems will be primarily experimental, using both piloted simulations and VTOL research aircraft. An integrated approach will be taken in the simulations, whereby, the SCS systems, the aircraft systems, and the guidance systems are studied in combination with one another. Parallel flight investigations will follow using existing VTOL aircraft. The unique aspect of the SCS problem which will be emphasized, as distinguished from VTOL terminal area research under RTOP 760-62-02, is the non-stationary landing and take-off surface. The research will be coordinated with the avionics studies.

W74-70115 **760-62-04**
Ames Research Center, Moffett Field, Calif.
SIMULATION MATH MODELS OF ADVANCED TRANSPORTS
Bradford H. Wick 415-965-5567
(791-94-01; 760-62-02; 760-63-03; 760-63-02)

Simulation models of all important aircraft concepts in the CTOL, RTOL, STOL and V/STOL commercial transport classes are required to support the study of terminal area efficiency factors. To permit valid comparisons, the models of all competing concepts must be designed to the same level and technology and, where possible; for the same mission. Computer storage for each element of the terminal area study must be minimized to avoid exceeding the computer capacity. Aircraft models therefore, must be as simple as possible consistent with the aim of providing representative pilot handling qualities. Models will be produced in two phases. In phase 1, existing transport aircraft models will, be modified, in-house, to conform, where possible, to common guidelines and design criteria. In phase 2, running concurrently with phase 1, design studies for each concept will be performed under contract and the associated models produced either under contract or in-house as appropriate.

W74-70116 **760-63-02**
Ames Research Center, Moffett Field, Calif.
HELICOPTER AERODYNAMIC PERFORMANCE DYNAMICS AND NOISE
Leonard Roberts 415-965-5066
(760-63-03)

This RTOP covers research on performance, dynamic load, stability, control system, and noise characteristics of advanced helicopter concepts and configurations. Large scale wind tunnel tests will be conducted to evaluate these configurations and provide a data base to improve analytical techniques for future concept evaluation. Development of the multipurpose rotor test rig will be completed and the baseline rotor tested. A dynamic properties evaluation of the rotor test rig will be conducted to

ensure applicability to a wide variety of rotor systems. A series of rotors with modified tip planforms designed for noise reduction will be tested in the 40- by 80-foot wind tunnel. This will permit noise/performance trade offs and provide data for correlation with acoustic theory. Tests of the controllable twist rotor will be conducted to determine performance/stress trade offs. Tests of a hingeless rotor with hub moment feed back control will be made to determine transfer functions, open and closed loop. Tests of reverse velocity rotor will be made in the 12-foot wind tunnel. Theory for 3-D flow at the blade tip will be developed. Aircraft design studies of pure and compound commercial helicopters of the 1985 period will be made for the V/STOL short haul application to complement the tilt rotor studies under RTOP 760-63-03.

W74-70117 **760-63-02**
Langley Research Center, Langley Station, Va.
ROTORCRAFT AERODYNAMIC PERFORMANCE DYNAMICS AND NOISE
R. E. Bower 703-827-3285

Analytical and experimental studies will be made to identify factors contributing to the aerodynamic, structural, and noise characteristics of rotors. University grants and contracted studies will be continued to define wake geometry and analytical procedures which include wake characteristics in predicting airloads, structural response, performance, and noise. In-house experimental studies will be continued to better define unsteady local flow parameters significant in rotor blade section lift analysis and blade airfoil development. Analytical, wind tunnel, and whirl tower investigations will be made to determine performance, dynamic loads, vibrations, and noise characteristics of advanced rotor concepts, rotorcraft configurations, and tail rotor arrangements. Work will proceed on the necessary studies, supporting technology, and design of a series of advanced rotor systems in order to begin flight testing on the RSRA in FY-1976. These programs will, in general, be carried out jointly with the Langley Directorate of the Army Air Mobility R and D Laboratory.

W74-70118 **760-63-03**
Ames Research Center, Moffett Field, Calif.
TILT ROTOR AIRCRAFT AERODYNAMIC PERFORMANCE
Leonard Roberts 415-965-5066
(760-63-02)

This RTOP covers activities in research and supporting technology for the tilt rotor aircraft program to provide a sound base for definition of performance, dynamic loads, stability, control systems, and noise characteristics of advanced tilt rotor concepts and configurations. In-house development of a 4 and 9 degree of freedom math model of tilt rotor dynamics was completed, and correlated well with full scale wind tunnel data. Development of more sophisticated models of the complete aircraft and its subsystems will continue, including control systems for mode suppression. Contracted analyses and tests will be conducted for rotor control systems for gust alleviation and blade load suppression. Contracted aircraft design studies of tilt rotor commercial aircraft for the 1985 period will be made for the V/STOL short haul application to compliment helicopter/compound studies under RTOP 760-63-02. In-house development of a theory for the 3D blade tip aerodynamics for performance and noise evaluation will be started. Contracted analyses and tests will be initiated to study rotor/wing/tail interference problems. Contracted analyses will be made to evaluate the cost of noise reduction for tilt rotor aircraft.

W74-70119 **760-63-04**
Langley Research Center, Langley Station, Va.
ROTORCRAFT FLIGHT DYNAMICS
R. E. Bower 703-827-3285
(768-82-02; 501-23-11)

Using broad capability helicopter in-flight simulators as primary tools, research will be conducted to develop improved design and certification criteria (primarily in areas of handling qualities and overall flight characteristics) for various classes of VTOL vehicles such as lift-fan transports, as well as helicopters and other rotorcraft. Also conducted will be the research required for both manual IFR flight simulations, as well as for advanced vehicles having automated flight and active control capability with satisfactory provision for pilots to monitor and take over flight control manually with particular emphasis on flight in the terminal areas. Representative types of problems to be investigated include defining the requirements and flight/operational characteristics of advanced flight control systems including active controls, inherent stability and augmented stabilization, cockpit displays and pilot controls including pilot workload, vehicle/piloting interfaces with groundbased and onboard navigation systems for manual flight in IFR conditions, and vehicle/piloting interfaces with automated flight systems. The CH-46 in-flight simulator will be used heavily in FY-1974 and preparations made to phase in a CH-47 in-flight simulator with improved capability. The SH-3A test helicopter will be used for cockpit display-pilot workload studies, and the large CH-54 helicopter will examine size and weight effects on handling qualities. Handling qualities research on the X-22 aircraft will be conducted by this RTOP (joint Navy/Air Force/FAA/NASA program with NASA funding provided directly by NASA Headquarters).

W74-70120 **760-63-04**
Ames Research Center, Moffett Field, Calif.
ROTORCRAFT FLIGHT DYNAMICS - TILT ROTOR AIRCRAFT
Bradford H. Wick 415-965-5570
(767-78-01)

The handling qualities, flight dynamics, and flight control of tilt rotor aircraft will be investigated in a combined analytical, simulation, and flight program to provide the data base needed by civil and military operators. Initial research will be centered on the Tilt Rotor Research Aircraft in conjunction with the Tilt Rotor Research Aircraft Project Office (RTOP 767-78-01). Mathematical models of larger size, commercial tilt rotor aircraft will be made available through another RTOP (760-62-00). Studies of these aircraft will emphasize development of satisfactory handling qualities for terminal area operation of tilt rotor aircraft. Flight research will be conducted on the Tilt Rotor Research Aircraft. Simulations will be conducted to develop satisfactory handling qualities for helicopters in the 100,000 to 200,000 pound class. The simulation will be validated through a coordinated simulation flight program of the CH-54B.

W74-70121 **760-63-05**
Langley Research Center, Langley Station, Va.
CIVIL HELICOPTER ADVANCED TECHNOLOGY
R. E. Bower 703-827-3285
(760-63-02)

The required improvements in present generation helicopters to achieve passenger acceptance will be identified. Hardware modifications will be established that would achieve significant improvements in performance, maintainability, passenger and community acceptability, and operational suitability of existing helicopters in civil applications. Design information will be developed for the next generation of helicopters which could incorporate known advanced technology to enhance suitability for civil applications. The value of application of this technology will be assessed to provide guidance in determining policy toward development of advanced civil helicopters as a national product. Criteria will be established through an experimental flight program using a military-type helicopter modified through addition of an air-conditioned passenger compartment and of acoustic, vibration, and motion-reduction features to provide a passenger-acceptable ride in smooth air at moderate speeds and in straight and level flight. Subjective experiments will then be made to study systematic degradation of the environmental factors which are expected in real-world operations (higher cruising speeds, gusts, and maneuvers) to establish upper boundaries for passenger acceptance. Contractual research will be carried out to identify available advanced technology improvements that could be applied to existing vehicles to better suit them for air carrier use, and to develop viable designs of next generation vehicles with incorporation of known technology advancements in a well-balanced fashion. Experimental evaluation of candidate improvements will be carried out. Surveys of existing helicopter air carrier

operations will be carried out to identify and evaluate problems and problem-solution approaches.

W74-70122 **760-63-06**
Langley Research Center, Langley Station, Va.
ROTOR SYSTEMS FOR ROTOR SYSTEMS RESEARCH AIRCRAFT
R. E. Bower 703-827-3285

In order to insure timely technology development and demonstration, and to provide maximum efficiency of utilization of the Rotor Systems Research Aircraft, research rotor systems will be selected, designed, fabricated and flight tested. A program of hardware development and flight experiments will be defined for testing of current and advanced technology rotor systems through a broader flight envelope to establish focused and effective technology advancements for rotors and rotorcraft. Three major elements will be initiated: These are as follows: (1) preliminary design, (2) concept evaluation and selection, and (3) hardware verification. Preliminary Design. - Preliminary design studies of an advanced Aero/Acoustic Rotor (A/AR) for the RSRA will be initiated. Concurrent with these basic system design activities, exploratory testing of several rotor blade geometric configurations will be conducted to provide system design verification and correlative data for blade design and selection techniques. Concept Evaluation and Selection. - Recognizing that there are numerous advanced rotor concepts in various stages of development, a complete review of these rotor systems will be conducted in-house. This review will establish interfaces with appropriate manufacturers and/or sponsoring government agencies to ascertain status of the concepts, potential, and development requirements prior to entering into the hardware definition phase for the RSRA systems development. Hardware Verification. - Two advanced rotor concepts which will receive particular emphasis are the Variable Geometry Rotor (VGR) and the Composite Structures (Bearingless) Rotor. Preliminary design analyses of a VGR configuration will be initiated as well as---

W74-70123 **760-64-01**
Langley Research Center, Langley Station, Va.
TRANSONIC AIRCRAFT-AERODYNAMIC PERFORMANCE
R. P. Bielat 703-827-2252
(501-06-05; 760-64-60)

The technical objective is to provide the required experimental and analytical data base to evaluate and improve configuration aerodynamic performance, stability, and control characteristics of advanced high subsonic aircraft concepts in cruise and maneuvering flight. Particular emphasis will be on exploring advanced or novel concepts, and on generating a better understanding and improvement of available concepts such as the area rule for lifting conditions and supercritical wings. (With regard to transport configurations, the objective is not to provide systematic design type data on the two optimized transport configurations supported by RTOP 760-64-60.) Promising ideas for improved advanced high subsonic aircraft concepts will be examined analyticaily and experimentally with primary emphasis on investigating their aerodynamic performance, stability, and control. Representative promising concepts which may be investigated include configurations employing improved supercritical wings; advanced second order or lifting area rule principles; cylindrical stretchable fuselages with optimum compromised area ruling done by glove, nacelle and pylon arrangements; and novel engine and nacelle pylon arrangements such as wing tip mounted engines to reduce the drag due to lift. The testing will be done primarily in the 8-foot tunnel, with additional testing in the 7- x 10-foot and 16-foot tunnels. The models will be either newly conceived models or modifications of exisitng models such as those used in tests in the Cornell Aeronautical Laboratory 8-foot tunnel.

W74-70124 **760-64-01**
Ames Research Center, Moffett Field, Calif.
SUBSONIC/SONIC AIRCRAFT AERODYNAMIC PERFORMANCE
H. M. Drake 415-965-5851

This RTOP covers investigations of the aerodynamic performance, stability and control characteristics, and airport and community noise characteristics of the R. T. Jones oblique wing transport aircraft configuration at subsonic, transonic and low supersonic speeds, and the adequacy of existing aerodynamic prediction methods for this class of vehicle. This information will be used for mission studies to assess the antisymmetric configuration potential for advanced transport consideration. Concurrently, an analytical and experimental investigation of nacelle-airframe interference effects on engine type and nacelle size, shape and location will be made. A study also will be initiated of an oblique wing on an F-8 scaled model to determine the feasibility of the F-8 for concept demonstration. This effort is to be coordinated with the flight group at FRC.

W74-70125 **760-64-03**
Ames Research Center, Moffett Field, Calif.
CIVIL AIRCRAFT DEVELOPMENT TESTING
H. M. Drake 415-965-5851
(760-17-01)

In the course of developing commercial aircraft, aircraft companies seek time in the Ames wind tunnel facilities, on a fee basis, for the purpose of studying the Reynolds number sensitive characteristics of wing high lift devices at subsonic speeds and the drag, the static stability and control, and inlet airframe interactions of their designs at transonic speeds. The results of these studies are frequently of mutual benefit to both the aircraft company and to NASA.

W74-70126 **760-64-04**
Ames Research Center, Moffett Field, Calif.
CIVIL A/C DEVELOPMENT TESTING (OTHER GOVERNMENT ORGS. EXCEPT DOD)
H. M. Drake 415-965-5851
(760-17-01)

With due consideration of available manpower, funds, and obligations towards NASA research and projects, Ames supports other governmental agency and industry programs in aeronautics. The support consists of consultation, assignment of personnel to advisory committees or boards, and the conduct of tests in wind tunnels, or other facilities. The major portion of this effort is in support of the Department of Defense and is covered by RTOP 760-17-01: An additional RTOP is required, however, to cover the allotment of time to other NASA Centers and to governmental agencies other than the Department of Defense. In general, manpower and test time is allocated only when the need for special unique capabilities of the personnel or the equipment is evident, and the request is in the national interest.

W74-70127 **760-64-05**
Flight Research Center, Edwards, Calif.
DEFINITION OF A FLIGHT DEMONSTRATION OF OBLIQUE WING CONCEPT
William H. Andrews 850-258-3311

This test program will be directed toward the development and full-scale flight evaluation of a manned airplane, modified to demonstrate the oblique winged configuration concept, developed by Dr. R. T. Jones of the Ames Research Center. The test vehicle will consist of an LTV F8 airplane modified to incorporate an elliptical full span variable sweep wing (lambda = 0 to 60) fabricated to standard structural design specifications, and including lateral control and wing trailing edge, high lift devices. In addition, the basic airplane stability augmentation and control system will be altered as required to supplement the inherent stability and control of the modified test vehicle. A limited investigation of the lift, drag and stability of a modified 1/11.5 scale F8 fuselage-model incorporating a elliptical wing (aspect ratio of 12.7, length to chord of 10%) was conducted in the Ames 11-foot wind tunnel in February 1973. The results were encouraging in that they indicated that the proposed airplane modification is feasible. Additional tests are planned for June and August 1973 to further explore the feasibility of such a modification with an aspect ration 10 wing and to obtain longitudinal and lateral control data pertinent to simulation and control system design. Results of these tests will be used to establish a wing structural design criteria as well as the basic airplane fuselage and systems---

W74-70128 **760-64-60**
Langley Research Center, Langley Station, Va.
ADVANCED TECHNOLOGY SUBSONIC/TRANSPORT AERODYNAMIC DESIGN DATA
R. E. Bower 703-827-3838
(760-64-01; 501-06-05)

The technical objectives are to provide extensive design type aerodynamic data in areas of performance, stability, and control for one refined 3-engine candidate configuration, and one refined 4-engine candidate configuration of high subsonic cruise transport aircraft in both the cruise and terminal area speed regimes. The approach will be to: (1) conduct wind-tunnel tests on a continuing basis on advanced 3- and 4-engine transport configurations, and related wind-tunnel tests and analytical studies specifically aimed at investigating wing/pylon/nacelle interference; (2) continue research on overall nacelle configuration (powered and unpowered) having a high drag divergence Mach number; (3) investigate jet interference effects on advanced 3- and 4-engine transport configurations; (4) determine dynamic stability characteristics of advanced 3- and 4-engine configurations; (4) develop data base for incorporating active controls and advanced flight path controls in advanced transport designs; and (6) continue research on improved high-lift systems for advanced transport designs.

W74-70129 **760-65-11**
Langley Research Center, Langley Station, Va.
HIGH SPEED AERODYNAMICS
R. E. Bower 703-827-3285

The technical objective of this work is to provide the analytic methodology and a background of aerodynamic data throughout the speed range (up to about M = 4.5) for defining and optimizing the aerodynamic performance of high-speed aircraft configurations. The approach to be used will employ both theoretical and experimental investigations of generalized aircraft configurations to develop techniques for increasing aerodynamic efficiency; to determine means of managing the aerodynamic center variation with Mach number to attain low static margins without encountering regions of static instability; and to develop new aerodynamic control concepts to provide maximum aerodynamic control effectiveness with a minimum of control force.

W74-70130 **760-66-01**
Langley Research Center, Langley Station, Va.
HYPERSONIC AIRCRAFT AERODYNAMIC PERFORMANCE
R. E. Bower 703-827-3285
(501-04-03)

The purpose is to provide the technology for the design of efficient, practical, hypersonic air breathing aircraft. A number of aircraft systems are being studied. These include hypersonic transports, military strike and reconnaissance vehicles, hypersonic research airplanes, and the air breathing launch vehicle. The air breathing launch vehicle which is capable of providing a truly low-cost space logistics system can fill an expected need in the NASA/DOD program in the 1985-1995 time period. The hypersonic transport, with its long range capability and cruise sonic boom levels that may be acceptable over populated areas, has the potential of providing a major step in air transportation in the latter part of the century. Air breathing vehicle systems must fully exploit the interactions between aerodynamics, propulsion, structures, trajectory selection, etc., to achieve maximum overall efficiency and operational flexibility. Detailed work on configuration concepts, reliable prediction techniques, full-scale Reynolds number effects, engine-airframe integration, etc. will be vigorously pursued to provide the technological base necessary. The technology for all three systems needs to be demonstrated in flight before committment to mission hardware is made. The hypersonic research aircraft will be used as a focal point in the technology development.

W74-70131 **760-67-01**
Langley Research Center, Langley Station, Va.
MILITARY AIRCRAFT - HIGHLY MANEUVERABLE AIRCRAFT TECHNOLOGY
R. E. Bower 703-827-3285

The technical objectives of this work are to develop advanced concepts which will provide the aerodynamic technology for the design of future military aircraft, and to assess the impact of advanced technology on combat performance. Research conducted under this RTOP will provide the configuration aerodynamics and performance technology for the NASA Highly Maneuverable Aircraft Technology Program. The approach to be used will combine both analytical and experimental studies of the integration of advanced aerodynamic concepts such as supercritical aerodynamics, wing warp, maneuver devices, thrust-induced lift, and component interference in the design of complete aircraft configurations. Particular emphasis will be placed on the improvement of performance and stability-and-control characteristics in the high angle-of-attack range at subsonic, transonic, and supersonic speeds. The differential maneuvering Simulator will be used to systematically assess the impact of advanced aerodynamic concepts on air combat performance.

W74-70132 **760-67-01**
Ames Research Center, Moffett Field, Calif.
MILITARY AIRCRAFT - AIRCRAFT AERODYNAMICS
Leonard Roberts 415-965-5066
(501-26-04)

Experimental and analytical studies will be made to provide the aerodynamic technology for design of advanced military aircraft. Large-scale low-speed wind tunnel studies will be conducted on components and integrated configurations to derive information on high-lift devices, lift and drag, stability and control effects of engine power, and effects of variations in wind geometry. Mutual aerodynamic interference effects between the airframe and propulsion system for conventional and oblique wing aircraft, including RPV class vehicles, at subsonic, transonic, and supersonic speeds will be investigated. The effect of fuselage geometry and inlet location on aircraft and inlet performance will be determined. Various numerical analysis and approximation techniques will be employed; the approximation techniques to serve as a basis for the detailed numerical study, and to aid in defining cost effective experimental programs. Wind tunnel studies will be made over the Mach number range to verify the analysis, and to evaluate the mutual aerodynamic interference effects between the airframe and propulsion system that are beyond the scope of present analytical methods. Oblique wing aircraft have application to a large number of military missions. Several advanced technology features are being investigated in a low cost RPV flight program. The objective of this program is to investigate the aerodynamics and operational features of low aspect ratio oblique winged vehicles, including performance, control laws, and static and dynamic stability for steady state and maneuvering flight.

W74-70133 **760-67-02**
Langley Research Center, Langley Station, Va.
MISSILE AERODYNAMICS
M. L. Spearman 703-827-3134

The objective is to develop advanced concepts which will provide the aerodynamic research and technology for the design of improved missile systems. The approach to be used will combine both analytical and experimental techniques. Studies will provide the technology for advanced missiles at all speeds for various mission requirements including the aerodynamic stability and control characteristics of surface-to-air, air-to-ground, air-to-air, and surface-to-surface missiles with wing, tail, canard, or jet controls. Missile configurations will be developed for future application through mission determination, trade studies, and performance evaluations. Emphasis is to be given to aerodynamic problems of fundamental importance to a class of configurations to permit a later selection for a specific development.

W74-70134 **760-67-03**
Langley Research Center, Langley Station, Va.
MILITARY AIRCRAFT - VECTORING IN FORWARD FLIGHT
R. E. Bower 703-827-3285

The technical objective is to develop and explore the benefits of thrust vectoring including thrust reversing or increased maneuverability at transonic and supersonic speeds for advanced fighter aircraft. The approach will be to define specific capabilities

of thrust vectoring and thrust reversing and provide design information for advanced highly maneuverable fighter aircraft in ait-to-air combat. It is planned to publish the results of the first phase and implement the second phase of the cooperative VIFF program research program with the British Ministry of Defence. There are two programs included within Phase II which may be identified as: (1) Harrier flight trails and ground attack research at Royal Aircraft Establishment following modification of XV-277 to permit use of VIFF throughout its flight envelope. NASA to arrange for USMC participation during ground attack trails. (2) Explore the effectiveness of thrust vectoring to 130 deg at NASA with the Kestrel aircraft, to be modified by McDonnell Douglas, to allow 130 deg vectoring within the envelope of 450 KIAS/0.9M above 10,000 feet and 90-percent engine fan speed, NASC has expressed strong support for this program as an input to their advanced Harrier concept.

W74-70135 **760-67-05**
Flight Research Center, Edwards, Calif.
MILITARY AIRCRAFT REMOTE CONTROLLED VEHICLE
G. P. Layton 805-258-3311

This program involves the design and construction of three 3/8 scale remote piloted F-15 flighter aircraft configurations to be air-launched, flown through high angle-of-attack maneuvers, and recovered by horizontal landing on Edwards Dry Lake or by parachute recovery. These vehicles are to be flown to gather needed flight data at angle-of-attack values at, near, and beyond the aircraft stall and departure. The overall objectives are to develop a remote controlled test technique that is suited to stall/spin type research; to obtain high angle-of-attack data specifically for a 3/8 scale F-15 configuration up to and including post-stall, pre-spin conditions; and to assess advanced control systems in pre-stall, post-stall, and pre-spin flight.

W74-70136 **760-17-01**
Langley Research Center, Langley Station, Va.
DOD ASSISTANCE - SPECIFIC MILITARY DEVELOPMENT PROGRAMS
R. E. Bower 703-827-3285

The objective is to determine the aerodynamic characteristics of models and model components at subsonic, transonic, and supersonic speeds. Current emphasis is focused on the USAF B-1, USAF YF-16, USAF YF-17, USAF A-10, USN V/STOL prototype, and several foreign vehicles. Results will be obtained by means of wind-tunnel investigations conducted over appropriate ranges of aerodynamic variables to determine forces, moments, and loads, as well as by the use of the many available analytical programs. Analysis of the results will be performed and documented.

W74-70137 **760-17-01**
Ames Research Center, Moffett Field, Calif.
DOD ASSISTANCE
Leonard Roberts 415-965-5066
(760-67-01)

Technical assistance, consultive services, and facility support will be provided to the DOD in support of aircraft development programs. Included are research efforts to develop new criteria to aid in assuring satisfactory handling qualities of piloted aircraft, and to define and develop techniques for improvement of marginal or unsatisfactory handling characteristics of new airplane designs. Ground based and airborne flight simulators will be employed as required. Specific weapon systems programs for which support is planned during FY-1974 include the F-14, F-15, the B-1, the KC-135, the Light Weight Fighter, the A-10 and the Sea-Control Ship VTOL Aircraft, and the Advanced Military STOL Transport.

W74-70138 **501-08-10**
Wallops Station, Wallops Island, Va.
ATMOSPHERIC PARAMETERS
J. F. Spurling 703-824-3411

The objectives of this research program are: To develop an advanced state-of-the-art meteorological data-measuring and data-acquisition system. The measurements should include mean wind velocity, mean wind direction, the mean temperature, and the three turbulence components. The system needs to be flexible so that it can easily be adapted to measurements at different locations and to analyze recorded data and to study the effect of varying atmospheric conditions and varying surface roughness conditions of the low-level atmospheric turbulence. The results of the analysis of these data should be compared with existing theories and may also be the basis for new theories. The developed system will be used in the research programs carried out at NASA Wallops Station research airport. Additional research programs dealing with air pollution and aerodynamic excitation of structures will be generated upon completion of the proposed system. The current approach is as follows: (1) to design and to test an advanced state-of-the-art meteorological data-measuring and data-acquisition system for recording of the atmospheric turbulence in the atmospheric boundary layer; (2) to establish criteria for processing and analyzing the data, to develop proper calibration techniques, and to set appropriate standards; (3) to analyze the obtained results and to compare these results with existing theories; (4) to introduce new theories, describing the turbulence structure of the lower atmosphere; and (5) to make available to the NASA, to the scientific community, and to industry the results of this research program.

W74-70139 **501-08-10**
Langley Research Center, Langley Station, Va.
ATMOSPHERIC PARAMETERS
R. E. Bower 703-827-3285

Work is underway to investigate and define environmental factors of the atmosphere for use in the design, development and operation of CTOL and AST type aircraft. The work will be directed toward two specific areas. One involves the remote detection of turbulence in the atmosphere utilizing the Langley 48 in. Optical Radar System. An experiment is the optical radar system to enhance its capability for clear air turbulence work. The other areas is a continuing effort to define the radiation hazard for high altitude transport aircraft. Measurements were made through the last solar cycle and the final report is in preparation. Accelerator measurements of high energy protons and alpha produced neutron spectra continues along with theoretical alpha reaction model development.

W74-70140 **501-08-10**
Flight Research Center, Edwards, Calif.
ATMOSPHERIC PARAMETERS
L. J. Ehernberger 805-258-3311

The objective of this work is the definition of the atmospheric conditions in which turbulence, temperature transients, potential pressure altimetry problems, and excessive wind shears occur. The major emphasis is the atmospheric environment of supersonic aircraft. Development and acquisition of sensors needed to measure these phenomena are also included. Results of this work will be applicable to aircraft systems design as well as flight operations routing and scheduling. Observations of these phenomena are obtained from instrumented aircraft test flights. The associated meteorological conditions are analyzed and studied both in-house and on contract.

W74-70141 **501-08-10**
Marshall Space Flight Center, Huntsville, Ala.
ATMOSPHERIC PARAMETERS
George H. Fichtl 205-453-3168

The natural environment is one of the major considerations in the design and safe operation of aeronautical systems (conventional aircraft, helicopters, V/STOL vehicles, etc.). The objectives of the research under this RTOP are: (1) the utilitarian definition of the steady-state wind and turbulence environments which are encountered during the operational life of aeronautical systems for the design and safe operation of these systems, and (2) the feasible modification of fog at airports to improve visibility. The first objective will be accomplished through the development of empirical/theoretical models. In the atmospheric boundary layer (approximately first 2-kilometers of the atmosphere), these models shall define (1) the mean or steady-state wind profile, (2) steady-state and instantaneous wind shear, (3) the statistical properties of turbulence (spectra, higher-order statistics, etc.), (4) the modification of atmospheric flows as air

passes over and around buildings or natural obstructions and as air passes from rough to smooth and from smooth to rough terrain, (5) the structure of wakes behind buildings (aircraft control towers, airport facilities, etc.) and natural obstructions such as hills, trees, etc, and (6) the structure of the turbulent flow in the cold air outflow of thunderstorms. In the free atmosphere above the atmospheric boundary layer the first objective shall be accomplished through the development of probabilistic models of turbulence and the conditions which lead to turbulence. The second objective will be accomplished through analytical and laboratory studies and field testing programs relative to the life cycle of fog.

W74-70142 **501-38-12**
Langley Research Center, Langley Station, Va.
TIRE TRACTION, BRAKING
George W. Brooks 703-827-2042

Aircraft operations on prepared runways under adverse weather conditions and on certain unprepared surfaces present requirements on braking and steering systems, tires and runway that are vital to aircraft safety and passenger comfort as well as being necessary to procedures for alleviating airport congestion. The objectives of programs covered by this RTOP are: (1) to improve the performance of braking systems, (2) to improve the performance and lifetime of pneumatic tires, (3) to develop new landing gear systems that would permit operations on unprepared fields, including water, and permit continuous use of prime runways for all-weather operations, (4) to evaluate tire cornering behavior with and without braking such high-speed turnoffs can be designed to increase the flow of traffic at congested airports, and (5) to relate the character of the runway surface to aircraft braking and steering performance. Research to meet these objectives will employ full-scale aircraft, landing gear systems and subsystems, and scaled pneumatic tires. The test facilities will consist of the Aircraft Landing Loads and Traction Facility, airport runways, including the landing research runway at Wallops Station, ground test vehicles, and various laboratory equipment.

W74-70143 **501-38-12**
Ames Research Center, Moffett Field, Calif.
TIRE TRACTION, BRAKING
Glen Goodwin 415-965-5065
(501-38-19)

Objectives are to: (1) improve aircraft braking and control on the runway by the utilization of improved materials for aircraft tires and brake linings; (2) develop and evaluate improved elastomeric materials for use in tires for present and future high speed aircraft having improved properties and less wear and blowout than conventional aircraft tire materials; (3) develop and evaluate composite materials based on high temperature composites which could serve as long wearing and improved frictional materials for aircraft brake linings. Tread vulcanizates composed of improved elastomers and various polyblend of natural rubber will be evaluated by performing stress relaxation measurements and other tests. Improved processing and curing methods will be sought in order to yield elastomeric materials having improved thermochemical and physical properties, especially at elevated temperatures. Tires will be retreaded with the improved elastomers and evaluated in actual commercial airline service and in simulation tests. Failure modes of tire carcass will be studied. Brake lining compositions based high temperature composites will be evaluated on a brake tester, and other tests will be performed to assess their performance as improved linings for aircraft. Other studies will include composite formulation, processing otpimization, brake lining fabrication and evaluation of brake performance.

W74-70144 **501-38-18**
Langley Research Center, Langley Station, Va.
CROSSWIND LANDING FOR STOL OPERATIONS
R. E. Bower 703-827-3285

The objective is to investigate STOL crosswind landing problems and methods of extending the crosswind limits for landing. A flight investigation will be conducted to determine the relation between airplane control, airplane response, piloting techniques, flight safety margins, and crosswind limits during STOL-type landing operations. An analytical study and model tests will be conducted to investigate crosswind landing gear configurations and a crosswind landing gear will be designed, built, and flight tested. Studies also will be made of control concepts such as the use of airfoil generated side force for crosswind landing control.

W74-70145 **501-38-11**
Langley Research Center, Langley Station, Va.
AIRCRAFT OPERATING EXPERIENCES
R. E. Bower

Statistical data on the operational experiences of general aviation airplanes are being collected and analyzed. The data are collected during routine operations by the use of NASA instrumentation. The data provide information on the ground and flight loads, airspeed and altitude operating practices, and the turbulence environment. The information obtained provides a continuous basis for comparing actual airplane operations with concepts used in design, for detecting unanticipated operational aspects, and provides a reservoir of data useful in the design and development of airworthiness requirements for new types of airplanes.

W74-70146 **501-38-13**
Flight Research Center, Edwards, Calif.
HAZARD AVOIDANCE
M. R. Barber 805-258-3311
(501-38-13; 501-06-04; 501-06-12)

The technical objectives are to: (1) provide flight test operational support for the NASA Wake Turbulence Research Program; (2) develop means of vortex visualization for flight test purposes, and (3) for possible operational use. Vortex visualization schemes such as oil smoke and diatomaceous earth are effective, but have some drawbacks when the vortex is probed by following aircraft. In addition, development of span-wise distribution of vortex marking substances will aid in evaluation of ground facility-derived aerodynamic modifications for vortex modification.

W74-70147 **501-38-13**
Lewis Research Center, Cleveland, Ohio.
HAZARD AVOIDANCE AND ELIMINATION
Solomon Weiss 216-433-6898
(501-38-12; 501-38-13)

The objective is to provide basic data for the improvement of the operational safety of civil and military aircraft. Through NASA supported research, which complements researches conducted by other segments of the aviation community, provide devices and techniques which overcome operational problems. These problems are presented by the desire to improve the safety of airplane operations while extending the mission of the airplane and improving the economics of its operation. Commercial and general aviation aircraft, including V/STOL, will be considered. Specific areas of current interest include: lightning hazards to aircraft avionics, rotor burst protection, detection of incipient structural failure, ozone hazard in high altitude aircraft, wind shear effects, icing tests, aircraft altimetry systems, aircraft braking improvements, and improvements in turbine disk design.

W74-70148 **501-38-13**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
HAZARD AVOIDANCE
Rob R. McDonald 213-354-6186

A practical approach to marking trailing vortices generated by large aircraft will be investigated, with emphasis placed on injection of non-polluting, biodegradable particulates. Several candidate marking materials will be identified based on consideration of their requirements and characteristics. A working model of a generating device, suitable for use in subsequent flight testing, will be designed, fabricated, and assembled.

W74-70149 **501-38-13**
Marshall Space Flight Center, Huntsville, Ala.
HAZARD AVOIDANCE AND ELIMINATION
R. M. Huffaker 205-453-1156

Using the laser Doppler technique, systems and instrumenta-

tion will be developed for measuring natural and induced atmospheric flow phenomena concentrating on aircraft wing tip vortices and clear air turbulence (CAT). The approach will be to: (1) perform design, analyses and test with ground based laser Doppler instrumentation to determine operational requirements, specifications, constraints and capability; (2) develop and test two- and three-dimensional systems for measuring atmospheric flow, concentrating on aircraft wing tip vortices; (3) develop and test a laser Doppler clear air turbulence detection system as appropriate on the ground and aboard an aircraft, evaluating test data and the findings as the basis for system modification to assure overall system performance goals.

W74-70150 **501-38-13**
Ames Research Center, Moffett Field, Calif.
HAZARD AVOIDANCE AND ELIMINATION (WAKE VORTEX)
Leonard Roberts 415-965-5066.
(501-06-12)

The trailing vortex systems generated by aircraft can be hazardous to other aircraft following along or near the same flight path. Flight test measurements will be made in order to increase the basic knowledge of the structure of trailing vortices and their dissipation mechanisms. This data will supplement and overcome shortcomings of wind tunnel and tower measurements. In addition, devices which show promise of accelerating the vortex dissipation in the wind tunnel can be quantitatively examined in flight. Hot wire anemometers will be mounted on the nose boom of a probe aircraft and will be used to gather velocity and temperature data at various separation distances. From the measured velocity data a picture of the total flow field will be constructed in space and time. Investigations will be made of the vortex wakes left by conventional aircraft as well as those left by powered-lift STOL aircraft.

W74-70151 **501-38-13**
Langley Research Center, Langley Station, Va.
HAZARD AVOIDANCE AND ELIMINATION
R. E. Bower 703-827-3285

The objective is to provide basic technology data for the improvement of the level of safety in aircraft operations. (1) Technical assistance is being provided to various agencies having safety of flight problems. (2) The feasibility of using Raman optical radar to obtain a remote measurement of visual ranges along the glideslope which will be usable to a pilot will be studied. (3) The investigation of means for accelerating breakup or dissipation of aircraft trailing vortices will be continued. (4) Studies of helicopter response to vortex encounter will be initiated.

W74-70152 **501-38-19**
Lyndon B. Johnson Space Center, Houston, Tex.
DEVELOPMENT PROGRAM OF IMPROVED AIRCRAFT CABIN MATERIALS
Richard W. Bricker 713-483-3166

The effort defined in this RTOP is a continuation of work started in FY-73. The FY-74 work will finalize the development of nonflammable aircraft fuselage insulation, inner cabin panels, decorative skin, windows, and evacuation slides. In addition, two refurbishments of portions of a 737 fuselage will be completed during FY-74 to support full-scale tests for evaluation of new nonflammable materials. Procurement of material specimens for laboratory tests will also be accomplished.

W74-70153 **501-38-19**
Ames Research Center, Moffett Field, Calif.
FIRE RETARDATION
Glen Goodwin 415-965-5065
(501-38-12)

The objectives are to: (1) develop designs and concepts of aircraft structures which would provide the maximum crash fire protection to passengers and crew in commercial aircraft; (2) develop fire-safe aircraft structure concepts for existing and future airframes utilizing Ames developed materials and other fire control systems in order to provide an increased probability of human survivability in crash fires; (3) provide sound absorption, vibration damping and isolation, and other structural benefits; (4) select the best materials such as foams, coatings, window materials and sealants for these applications. Studies and appropriate tests will be conducted to define the critical parameters of application and required performance of fire-retardant materials in aircraft. These parameters will include definition of the weight penalty, methods of application of fire-retardant materials and component inspection, evaluation of char forming windows and definition of other advantages of foam utilization such as aircraft floatation characteristics and acousical/vibrational damping effects. Appropriate design studies and tests will be conducted to prove some of the above concepts. Tests will include fire tests of retrofit configuration and physical environmental tests of materials involved.

W74-70154 **501-38-16**
Langley Research Center, Langley Station, Va.
FLIGHT TEST INSTRUMENTATION
G. B. Graves 703-827-3745

Customized sensors for flight research programs are being developed that are compatible with a recently-completed advanced data system. Sensors for measuring control position, air temperature, altitude, airspeed, and flow direction will be developed, modified, or adapted to provide customized measurements that conform to safety guidelines and physical and electrical restrictions.

W74-70155 **501-38-16**
Flight Research Center, Edwards, Calif.
AIR DATA SENSOR DEVELOPMENT
L. D. Webb 805-258-3311

The advanced-type research flights being conducted at FRC require the use of new and unproven types of sensors to obtain the desired research measurements. The objective of this program is the design, development and testing of advanced sensors particularly when the work is being done in advance of, or apart from, the vehicle on which it will ultimately be used. Examples of needed sensors are altimeters for use at high speeds and extreme altitudes, miniature pressure transducers capable of withstanding Mach 3 stagnation temperatures, pressure survey rakes suitable for measuring dynamic flows. Special compensated pitot-static probes, and miniature flow-direction sensors for determining local flow angularities. Whenever possible, off-the-shelf items will be used with flight suitability being determined in FRC labs. Development of new concepts will be sponsored if no available devices suit the needs.

W74-70156 **791-93-03**
Ames Research Center, Moffett Field, Calif.
ANALYSIS OF FUTURE CIVIL AIR TRANSPORTATION SYSTEMS AND CONCEPTS
G. C. Kenyon 415-965-5887

The objective is to provide systems analyses of future civil air transportation systems and concepts in order to identify promising aeronautical systems, determine optimum characteristics, and define technology requirements and costs associated with such systems. Studies of general aviation aircraft, CTOL, STOL, and VTOL transports for short-haul applications, advanced subsonic/transonic transport aircraft, and advanced supersonic transports will be conducted. Total system studies will be carried out considering all of the interactions between aircraft, airports, airways, community impact, and economics (both within the aviation industry and on a national basis).

W74-70157 **791-93-04**
Ames Research Center, Moffett Field, Calif.
ANALYSIS OF FUTURE MILITARY AVIATION SYSTEMS AND CONCEPTS
M. H. Waters 415-965-5887

The objective is to provide systems analyses of future military aviation systems and concepts in order to identify promising aeronautical systems, determine optimum characteristics, and define technology requirements and costs associated with such systems. Studies of current and projected tactical aircraft missions will be conducted to evaluate the future requirements of tactical aircraft design. Analysis of the impact

of future technologies and advanced weapon systems on the performance and costs of tactical aircraft will be performed.

W74-70158 **791-93-05**
Ames Research Center, Moffett Field, Calif.
SHORT HAUL TRANSPORTATION SYSTEMS ANALYSIS
R. H. Petersen 415-965-5886

The objective is to help develop a sound technological base for future decisions relating to the design, development, and operation of short haul transportation systems. This objective will be achieved through a related group of studies that: examine the relationships between short haul technology and short haul economics, markets, and implementation; identify potential viable short haul airplane concepts and their design and performance criteria for practical short haul transportation systems including consideration of market, economic, and environmental factors; and, perform sufficient aircraft design to provide a realistic assessment of technical problems and questions regarding their design, development and operations, and their development and operational costs. These data will be used to help define the future direction of productive technical (and system related) activity for short haul transportation systems. This investigation will be performed in-house and under contract. Two contracted studies (Lockheed and Douglas) to determine the operational and economic viability of turbofan powered propulsive lift aircraft for short haul transportation have been completed. Final reports will be distributed in June. The current contracts have been extended to (1) allow Lockheed to optimally design and compare the OTW/IBF propulsive lift and mechanical flap concepts in terms of noise impact and operation economics, and (2) allow Douglas to determine the impact on operating economics of the effect of combining terminal area operations with various engine cycles to minimize community noise impact for several propulsive lift and mechanical flap concepts.

W74-70159 **791-93-06**
Ames Research Center, Moffett Field, Calif.
HIGH TRANSONIC SPEED TRANSPORT (HITST) SYSTEM STUDY
H. M. Drake 415-965-5851
(760-64-01)

The objective is to provide detailed configuration definition of a high transonic speed transport concept. The contract system study of FY-1973 identified a promising yawed wing aircraft at the conceptual design level. The study this year will provide needed definition at a more detailed level, providing in-depth analysis in several individual new technology areas, and adding credibility to certain design concepts. Examples of such design studies would include fatigue and flutter characteristics of composite structures, low speed stability and control of yawed wing for emergency maneuvers, and new engine technology applications for reduced noise. This effort will be a competitive study at a cost of 175K$. The work will involve roughly 8 man-years effort for a period of 6 months and will begin in November 1973.

W74-70160 **791-93-07**
Ames Research Center, Moffett Field, Calif.
STUDY AND ANALYSIS OF FUTURE NATIONAL NEEDS AND POTENTIAL AEROSPACE CONTRIBUTIONS TO MEET THOSE NEEDS
Harold Hornby 415-965-5894

The objectives of this RTOP are: to enhance our techniques for the investigation, identification and optimization of future U.S. Transportation R and T Strategy based upon forecasts and analysis of future societal environments and technology; to utilize technology forecasting and assessment as a component of this R and T strategy formation process, using a simplified forecasting model directed at developing a transportation system R and T strategy; and to improve and refine methods for the strategic selection of high technology aerospace goods and services fostering a favorable U.S. balance of trade.

W74-70161 **791-93-09**
Ames Research Center, Moffett Field, Calif.
ANALYSIS SUPPORT FOR AERONAUTICAL PROGRAM PLANNING
D. E. Wilcox 415-965-5887

The objectives are to provide special, short term studies in support of the aeronautical program planning activities of ARC and OAST, and to perform the necessary in-house and contractual subsystem and discipline-oriented studies in support of the more general total systems studies conducted by the Systems Studies Division(ARC).

W74-70162 **791-93-12**
Ames Research Center, Moffett Field, Calif.
AERONAUTICAL SYSTEM ANALYSIS (ACSYNT)
H. M. Drake 415-965-5851
(791-91-03)

The objective is to develop an overall system synthesis capability which can identify the best system characteristics for any air transportation system. Mathematical models of the air vehicle elements will be developed and verified by comparison with operational situations.

W74-70163 **791-93-13**
Lewis Research Center, Cleveland, Ohio.
AIR-BREATHING PROPULSION STUDIES
R. J. Weber 216-433-6273

In-house and contracted studies will be performed of engine cycles, complete propulsion systems, and integrated engine/airframe combinations applied to representative airplane missions. The object of the studies is to determine desirable engine component and system design characteristics for future aircraft, and to identify technology deficiencies and profitable areas for research.

W74-70164 **791-93-14**
Ames Research Center, Moffett Field, Calif.
QUIET PROPULSIVE-LIFT TRANSPORT TECHNOLOGY-SYSTEMS STUDIES
D. E. Reese 415-965-5687
(791-93-01; 791-93-03; 791-93-05)

The objective of this effort is to identify, through aircraft definition and transportation systems studies, the problem areas, configurations and technology for emphasis in future quiet propulsive-lift technology programs, including flight research. The results of current short-haul (STOL) transportation systems studies will be evaluated and used to define related technology requirements. As an essential part of the effort, advances and new capabilities in propulsive-lift technology will be evaluated, in-house and under contract, to establish the impact these may have on the direction and conclusions of the transportation system studies. The current short-haul (STOL) studies will be expanded to include considerations of propulsive-lift to long-haul transportation and to CTOL and RTOL as well as STOL aircraft.

W74-70165 **791-93-16**
National Aeronautics and Space Administration, Washington, D.C.
NAE/ASEB COMMITTEE ON ALTERNATE AIRCRAFT FUELS
Paul G. Johnson 202-755-3227

This RTOP provides financial support for an ad hoc Committee on Alternate Aircraft Fuels of the Aeronautics and Space Engineering Board, National Academy of Engineering. The committee is formed in response to a NASA request for outside advice and counsel in the area of future aircraft fuel as influenced by energy trends and projected fuel shortages. The committee is to conduct an independent study and report their findings and recommendations to NASA management.

W74-70166 **791-93-18**
Ames Research Center, Moffett Field, Calif.
STUDY OF POTENTIAL UTILITY OF RPV'S (REMOTELY PILOTED VEHICLES) FOR CIVIL APPLICATIONS
Thomas J. Gregory 415-965-5881
(791-93-19)

Studies will be conducted to identify and describe the potential civil market for RPV's, to assess the associated benefits and costs of using these vehicles, and to identify likely candidate

vehicle concepts and the technology required to satisfy civil markets. In addition, the study will include an assessment of the impact of safety, reliability and environmental requirements on the future use of civil remotely piloted vehicles.

W74-70167 **791-93-51**
Langley Research Center, Langley Station, Va.
VLF WIDE AREA NAVIGATION FOR LOW-DENSITY SHORT HAUL TRANSPORTATION
G. B. Graves 703-827-3745
(501-03-02)

The objective is to investigate VLF navigation techniques and to develop promising approaches for en-route and terminal area navigation. Systems such as Omega can provide large geographic coverage with a limited number of ground stations, and are relatively unaffected by altitude or terrain. Characteristics such as these are highly desirable for short-haul, low-density transportation systems, where direct terminal-to-terminal routes at relatively low altitudes are required. The application of VLF navigation to civil aviation will also enhance air safety by reducing pilot navigating within a network of approximately 1000 VOR stations. Work will be conducted in two areas. The first area consists of the measurement and analysis of errors due to propagation anomalies and atmospheric noise. The second area consists of the development and evaluation of Omega avionics, including both differential and composite Omega configurations.

W74-70168 **791-93-60**
Langley Research Center, Langley Station, Va.
SUBSONIC/SONIC CTOL TRANSPORT TECHNOLOGY SYSTEMS AND DESIGN STUDIES
R. E. Bower 703-827-3285
(766-73-60; 760-64-60; 768-81-01; 768-81-02; 770-18-04)

This RTOP covers the continuation of systems and design integration studies for subsonic C/RTOL long- and medium-range transport aircraft. The objective is three fold: (1) to quantitatively evaluate benefits and costs of advances in technology that provide potential improvements in aircraft operational (safety, efficiency, congestion relief, etc.) and environmental (noise, chemical pollution, etc.) characteristics; (2) to define both R and T needs in the various disciplinary areas and ground based and flight technology - validation and demonstration programs; and (3) to improve the in-house capability for evaluating weights, cost, economics, and performance of advanced transports. The approach includes: (1) continuing exploratory in-house studies of new concepts with contracted follow-up studies to greater depth on those that appear promising, and utilizing in-house and contractor capabilities for increasing the accuracy of in-house systems-type analytical methods for estimating transport weight, cost, economics, and performance.

W74-70169 **791-93-61**
Lewis Research Center, Cleveland, Ohio.
SUBSONIC/SONIC CTOL TRANSPORT TECHNOLOGY PROPULSION STUDIES
E. W. Conrad 216-433-6369
(791-94-08; 501-24-07)

NASA has initiated an effort to study the application of advanced technology to the improvement of future commercial transport aircraft. The results were resolved in terms of economic factors involving parameters such as aircraft drag, propulsion efficiency, costs, and propulsion system noise and exhaust emissions. Detailed analyses have been completed through in-house and contract studies and have been documented in NASA Contractor Reports. Results indicated that the environmental constraints imposed compromises to the optimum fixed-area turbofan cycle with resulting economic penalties. The studies also indicated areas where advanced technology would decrease the noise and emissions and improve the system economics. Results of recent studies of unconventional cycles have indicated that to achieve low noise, variable geometry inlets in conjunction with variable-area exhaust nozzles will be needed. Also, the use of high throat Mach number inlets appears to offer significant performance and economic improvement over inlet splitter rings. Several designs, including hybrid variable geometry cowls, expanding and translating centerbody types, and translating ring-type inlets were proposed for further study.

W74-70170 **791-94-02**
Ames Research Center, Moffett Field, Calif.
VTOL VEHICLE STUDIES
W. L. Cook 415-965-5486
(760-62-02)

The technical objectives are: to acquire preliminary design information for a possible V/STOL lift-fan transport research aircraft based on various lift-fan propulsion system arrangements, to acquire conceptual design information for V/STOL jet lift commercial short-haul transports, to gain a better understanding of potential aerodynamic problems and enable preliminary examination of terminal area flight characteristics, and to examine the potential of applying lift fans and other jet lift V/STOL concepts to military aircraft designs. Contracted and in-house engineering studies will be initiated (or extended) to provide better technical input to feasibility evaluations of a proposed lift-fan research aircraft. The adequacy of the research aircraft to provide the transport design data required will be determined to some extent by results of parallel design studies of representative commercial lift-fan and other jet lift V/STOL transports. Recently initiated contracted studies of the application of jet-lift technology to military aircraft will be expanded. Math models of the research, civil, and/or military transport aircraft will be provided for simulation studies carried out under RTOP 760-62-02.

W74-70171 **791-94-05**
Flight Research Center, Edwards, Calif.
HIGHLY MANEUVERABLE AIRCRAFT TECHNOLOGY (HIMAT)
D. R. Bellman 805-258-3311

This RTOP covers an analytical and experimental program for the development of an improved technology for the design of highly maneuverable aircraft. Present design constraints will be relaxed to permit complete freedom in the application of state-of-the-art systems such as integrated, computerized controls, composite structures, supercritical airfoil technology, vectored thrust and the like in order to achieve the maximum benefits from synergistic effects. In an initial procurement, approximately 9 contractors will be asked to bring forth their ideas, possible innovations, and general approach towards the improvement of the design technology for highly maneuverable aircraft. In a second contract phase, some of the initial contractors will be selected to develop their ideas into a usable design system. Results will be used to formulate an RFP for the application of the technology to the design of a highly maneuverable combat aircraft and for the construction of large-scale flying models which will be tested by remote-piloting techniques at FRC.

W74-70172 **791-94-51**
Langley Research Center, Langley Station, Va.
LOW-DENSITY SHORT-HAUL TRANSPORTATION SYSTEMS - TRAVELER ACCEPTANCE FACTORS
R. E. Bower 703-827-3285
(501-29-12)

The objective is to identify and examine in detail those factors influencing acceptance and use of aircraft by the public in the low-density short-haul market. The approach will be to carry out studies, principally by grant and/or contract, which will include surveys by questionnaire, measurements aboard airliners, data analysis, and math modeling. Questionnaires will be used to obtain the attitudes of various groups and types of travelers and of air carriers concerning ride quality, safety, convenience, travel time, cost, and other factors deemed significant. A data base for deriving a ride-quality model will be generated wherein measurements will be recorded of the environmental factors (e.g., noise level, motion/vibrations, temperature, etc.) and of correlated subjective reactions of the passengers during scheduled airline short-haul operations, of second- and third-level carriers. From the attitudinal survey analysis and ride-quality model, an evolving set of criteria will be established suitable for use to prescribe some of the technical requirements for a traveler-acceptable system; to assess the suitability of specific aircraft and/or operational procedures in meeting these requirements; and to

aid in structuring related systems studies, vehicle R and D efforts, and airline demonstration programs. The practical viewpoint of the aircraft operator will also be sought by engaging an appropriate air carrier to critique not only the criteria being developed herein, but also the assumptions and results of previous low-density systems studies as they relate to the passengers. The results will further define those aircraft features and characteristics considered desirable for viable and acceptable low-density short-haul service.

Aeronautics Systems and Experimental Programs

W74-70173 **738-69-01**
Lewis Research Center, Cleveland, Ohio.
QUIET, CLEAN SHORT-HAUL EXPERIMENTAL ENGINE (QCSEE)
Raymond J. Rulis 216-433-6651

The objective of this RTOP is to develop and establish the technology required for turbofan engines incorporating advanced noise reduction and emission reduction techniques needed to meet the expected stringent noise and pollution levels of future short-haul aircraft. The experimental engines which will be designed and built in this program, consolidate the technology for very quiet, clean, very high bypass ratio turbofan powered-lift propulsion systems, particularly applicable to future short-haul aircraft.

W74-70174 **743-29-11**
Langley Research Center, Langley Station, Va.
AST-SONIC BOOM ACCEPTABILITY
George. W. Brooks 703-827-2042
(501-29-11; 743-65-31)

The objective is to obtain criteria for the most severe sonic boom characteristics that will be compatible with high standards of environmental quality. These criteria will be developed as design goals for use in obtaining advanced technology for overland supersonic flights which will be acceptable to the public. Emphasis will be on laboratory tests to evaluate individual responses to sonic boom type exposures of varying physical characteristics. Both outdoor and indoor exposure situations will be considered along with operational occurrence characteristics. Individual responses in the laboratory will be projected to community responses and public reactions.

W74-70175 **743-31-01**
Ames Research Center, Moffett Field, Calif.
FUEL TANK SEALANTS
Glen Goodwin 415-965-5065
(501-38-12; 501-21-22)

This RTOP includes the following areas of sealants research and technology: synthesis, characterization, compounding, and curing of sealant elastomers; thermal degradation and stress relaxation of gum and filled sealants; interaction of titanium with sealants; measurements of their dynamic properties; and their application to fuel tanks in advanced aircraft for flight testing. The objective is to develop fuel tank sealants which offer long service life under conditions encountered in advanced supersonic aircraft. The specific objectives are to: synthesize, characterize and vulcanize sealant elastomers; study mechanism(s) by which they deteriorate on exposure to heat both in the presence and absence of fuels; select optimum sealant, and determine its thermophysical and dynamic properties; and evaluate it by performing appropriate environmental and flight testing. Novel elastomers will be synthesized as canadidate fuel tank sealants designed to meet flight requirements of Mach 2.7-3.0 and higher. The mechanism(s) of thermal degradation of these sealants will be investigated. Gum sealants will be selected, compounded, and tested under simulated fuel tank conditions to establish their long term service life. The optimum sealant will then be applied to a fuel tank in an advanced aircraft and flight-tested.

W74-70176 **743-31-24**
Lewis Research Center, Cleveland, Ohio.
AST MATERIALS
J. C. Freche 216-433-4000

The overall objective of these studies is to develop high temperature resistant polymers for use as matrix materials in advanced resin/fiber composites for AST structures. High temperature resistant polyphenylquinoxalines and polyimides with improved processability and elevated temperature strength retention characteristics in fiber composites will be developed. Studies currently underway directed toward improving the thermo-oxidative stability and processing characteristics of polyphenylquinoxalines will be continued. Studies to improve the autoclave processing characteristics and upper continuous use temperature of addition-type polyimides will also be performed. The work proposed in this RTOP differs from the work at Langley Research Center in the following two respects: (1) Polyphenylquinoxaline polymers will not be studied by Langley, (2) The polyimides being studied by Langley are of the conventional condensation type in contrast to the addition-type polyimides which are being studied at Lewis under this RTOP.

W74-70177 **743-32-01**
Langley Research Center, Langley Station, Va.
AST STRUCTURAL CONCEPT STUDIES FOR ADVANCED CONFIGURATIONS
George W. Brooks 703-827-2042
(743-32-02; 743-32-22)

The objectives are to: (1) assess relative merits of various structural concepts and materials for advanced supersonic aircraft configurations; and (2) determine the structural approaches best suited for the supersonic environment, and provide structural weight estimates based on in-depth structural design studies. Under contract, structural concepts will be developed for prescribed supersonic aerodynamic configurations. These concepts will be evaluated through design studies, making use of the best available materials technology, design tools, and design criteria, and through simplified cost-benefit studies. The best concepts which merit further evaluation by testing will be identified. Initial studies will focus on an arrow-wing aerodynamic configuration. Subsequently, similar studies will be carried out on advanced blended-body or variable-sweep configurations. Future work will also include study of impact of active controls on structural mass. In-house analytical studies using in-house developed and purchased analysis tools and mass estimation methods will supplement contract studies.

W74-70178 **743-32-02**
Langley Research Center, Langley Station, Va.
AST DESIGN, FABRICATION AND EVALUATION OF ADVANCED STRUCTURAL CONCEPTS
George W. Brooks 703-827-2042
(743-32-01; 743-32-22)

The objectives are to develop and evaluate advanced concepts and/or material systems for supersonic cruise aircraft structure, and to verify design technology associated with the concepts or systems. It is anticipated that the concepts to be evaluated will, for the most part, be identified by the concept design studies started with FY-73 funds under RTOP 743-32-01. Other concepts will be identified by in-house studies. Evaluation will consist of detail design, fabrication, and tests of selected elements and components under loadings characteristics of those experienced in a major structural assembly including tension, shear, compression, and thermal stress under both static and fatigue conditions. Appropriate components will be subjected to crack propagation and fail-safe testing. Tests conducted under FY-74 funding will be on relatively small elements and components where such testing supports and provides a logical build-up to larger component tests in future years. A large body of element testing is required, for example, to explore fabrication procedures and to determine local structural behavior such as buckling, crippling, and fatigue of joints and attachments before a large component can be adequately designed and fabricated. In other cases, larger components will be required for the early testing in order to achieve realistic structural characteristics. Work will generally be

done under contract except for fatigue and fracture testing of large panels which will be carried out in-house.

W74-70179 **743-32-11**
Langley Research Center, Langley Station, Va.
AST COMPUTER-AIDED STRUCTURAL DESIGN METHODS
George W. Brooks 703-827-2042
(743-32-01; 502-22-08)

The objectives are to: (1) develop computer-aided design methods with multidisciplinary capabilities for AST vehicles with particular attention to aeroelastic, flutter, thermal stress, and fatigue and fracture considerations; and (2) implement design methodology into operational modules (software) tailored for iterative design. Modules will be suitable for incorporation into integrated design systems or may be used as stand-alone design programs. This will provide results useful for assessment of the modules from design studies of candidate airframe designs for advanced supersonic transport configurations. Under contract, developments in unsteady aerodynamic loads and flutter calculation, thermal analysis, and thermal stress calculation procedures will be undertaken to improve their application in iterative design processes. Optimization techniques for resizing design of structural members under aeroelastic and thermal stress constraints will be developed. Under contract, the objectives are to collect, evaluate, and compress via analytic expressions fatigue and fracture data on materials suitable for the airframe structure of advanced supersonic aircraft; and to evaluate the feasibility of automating and catalog system for establishing the efficiency of joints in airframe structures.

W74-70180 **743-32-12**
Langley Research Center, Langley Station, Va.
AST LOADS AND AEROELASTICITY TECHNOLOGY
George W. Brooks 703-827-2042
(743-32-11; 743-32-13)

The objective is to develop technology in the area of loads and aeroelasticity to a sufficient state of readiness to provide an adequate base for confident initiation of development of advanced supersonic transports. Technical areas of interest include loads due to steady and unsteady motions of the aircraft and its component parts, high frequency acoustic pressure, and landing, takeoff and taxiing. Promising new approaches to the needed aerodynamic, dynamic and acoustic analyses will be vigorously pursued and focused on the needs of advanced supersonic cruise aircraft through a combination of in-house and contract research. The development of advanced flutter analysis theories will provide improved inputs to the flutter design module now being developed (743-32-11) particularly in the transonic and low supersonic speed regimes. Loads analysis techniques to include aeroelastic and nonlinear transonic effects will be developed. Both existing and new wind tunnel experimental results will be used to verify and improve analysis techniques. Acoustic pressure inputs from the engine exhaust will be quantified and the response of various structures will be analyzed. A program to predict aircraft landing, taxi and takeoff motion will be formulated and the benefits of an active landing gear on the ride quality and loads will be determined. Related work is being done at Langley, Ames, and Flight. The DOD/SST technical follow-on program has related task which have been considered in developing this program.

W74-70181 **743-32-13**
Langley Research Center, Langley Station, Va.
ATMOSPHERIC TURBULENCE MEASUREMENTS FOR APPLICATION TO AST
P. J. Bobbitt 703-827-3561

The technical objective is to obtain detailed definition of power spectra of turbulence and wave motion characteristics present in the atmosphere in various meteorological conditions. Special emphasis will be placed on the determination of the spectral shape at wavelengths of 30,000 ft or greater and altitudes of 30,000 to 65,000 ft. Meteorological conditions will include jet stream, mountain waves, gravity waves, and near thunderstorms as well as earth boundary turbulence measurements primarily for instrumentation verification. Consistency of spectra and directional characteristics of wave phenomena will be investigated. All measurements will be made with the same type airplane (B-57), the same instrumentation and same data processing procedure. Instrumentation includes low inertia flow vanes, an inertial platform for measuring aircraft motion angles, platform-mounted integrated accelerometers for aircraft velocities, and rate gyros for angular rates. A total of 60 to 90 flights over a two-year period should yield sufficient data to accomplish the objectives.

W74-70182 **743-32-14**
Flight Research Center, Edwards, Calif.
ANALYSIS AND TEST SUPPORT FOR GROUND AND FLIGHT VIBRATION TESTS
E. E. Kordes 805-258-3311
(743-36-21; 743-32-12)

The assessment of analytical and calculated response of flexible aircraft for aeroelastic studies requires complete and carefully documented dynamic test data on full-scale aircraft. Test results from both ground vibration tests and from flight tests at representative flight conditions are required. The YF-12 aircraft will be tested for complete symmetric and antisymmetric ground vibration modes up to about 30 Hz and flight tests will be conducted using specially built exciters to determine symmetric modes. The funds under this RTOP will be used for contractor effort to support the tests and to carry out NASTRAN calculations for comparison with test data.

W74-70183 **743-32-21**
Langley Research Center, Langley Station, Va.
AST MATERIALS AND STRUCTURAL COMPONENTS, TITANIUM
George W. Brooks 703-827-2042
(743-32-22; 743-32-23)

The objective of this program is to advance titanium materials and structural component technology in order to provide *combinations of materials and structural configurations that have* long-time structural integrity and low weight. To achieve this objective, a search program will be conducted on the important technology areas including advanced fabrication methods, strength and fatigue characteristics of components produced by advanced fabrication methods, development of methods for the acceleration of fatigue tests of titanium structures for AST environment, and the verification of the performance and capabilities of the fabricated hardware through in-service flight tests on the YF-12 airplane. The initial work will be accomplished with Ti-6Al-4V. Laser work will include studies of new or improved titanium alloys to determine their potential role in future supersonic aircraft. It is anticipated that this program will provide important advances in materials and structural component technology for advanced supersonic aircraft and will hopefully indicate approaches for achieving lower structural weight, improved structural integrity and lower fabrication costs.

W74-70184 **743-32-22**
Langley Research Center, Langley Station, Va.
AST MATERIALS AND STRUCTURAL COMPONENTS, COMPOSITES
George W. Brooks
(743-32-21; 743-32-23; 743-32-24)

The objective is to develop and improve composite materials and structural component technology in order to achieve longtime structural integrity and low weight in future supersonic aircraft structures. The technology development program will consist of investigations of time-temperature-stress limitations for different types of high temperature composite materials to determine their suitability for advanced supersonic aircraft applications. The program will also aim at development of new or improved resins, adhesives, and coatings; performance of strength, fatigue and fracture tests to establish structural integrity for various types of composite materials in representative components; and fabrication, ground test, and installation of suitable components on the YF-12 airplane for flight service evaluation. The effects of simulated longtime supersonic aircraft environment exposure on elements and components will be established. The development of fabrication methods and nondestructive evaluation techniques

will also be included. All of these programs will help to establish the future role of advanced composite materials in structural applications for supersonic aircraft and will help to generate the confidence required for the early application of such materials.

W74-70185 **743-32-23**
Flight Research Center, Edwards, Calif.
AST STRUCTURES AND MATERIALS TECHNOLOGY
Alan L. Carter 805-258-3311
(501-32-05; 501-32-06)

The objectives are to determine the structural performance of candidate AST materials and fabrication techniques (corrugated and honey comb sandwich, composites, conventional skin-stringer, etc.) subjected to load and thermal cycling. The approach will be to conduct a coordinated program of flight and laboratory tests on specimens supplied by Langley. For the flight program, representative panels would be designed, fabricated, and flight rated under contract, and installed on the YF-12 for exposure to realistic operating environment during NASA flight tests. Subsequently, the panels would be subjected to thermal and load testing in the FRC Heat Facility. In addition, a series of small element specimens, supplied by Langley, will be tested in the laboratory for additional background information.

W74-70186 **743-34-11**
Lewis Research Center, Cleveland, Ohio.
AST - NOISE REDUCTION TECHNOLOGY
U. H. von Glahn 216-433-6658

The objective is to develop the technology required to quiet both conventional and variable cycle advanced supersonic transport engines to levels acceptable to the community. Areas of particular concern include noise suppression of high velocity jets and choked inlet suppression of turbomachinery noise. Particular emphasis will be focused on the external flow effects on various jet noise suppressor types, and on the acoustic characteristics associated with engine cycles of interest for this application. Comparisons of in-flight jet noise measured on the ground with that obtained statically on the ground and in wind tunnel tests also will constitute an important segment of the work effort.

W74-70187 **743-34-11**
Ames Research Center, Moffett Field, Calif.
AST PROPULSION NOISE
Bradford H. Wick 415-965-5567
(501-04-01)

This RTOP covers research to reduce the noise level of supersonic aircraft. The noise comes from two sources: turbulent jet mixing from the engine exhaust, and compressor noise. Much research in these areas has been conducted in the past; however, nearly all was done at zero forward speed. Recent work has indicated that the jet turbulent mixing noise reduction expected at forward speed does not occur with mixer suppressor nozzles. From the standpoint of compressor noise, distortion at the compressor face arising from aircraft attitude and flow around the airframe can increase noise. It can probably be avoided by proper engine placement and/or careful inlet design. Solution of these problems requires research at forward speed in a ground based facility, that is, in a wind tunnel. Work will be completed on the validation of techniques for measuring jet noise in the wind tunnel. Additional work will be initiated on relative velocity effects on jet noise; and a theoretical and experimental effort on the dynamic effects of noise propagation in a wind tunnel.

W74-70188 **743-34-11**
Langley Research Center, Langley Station, Va.
AST - NOISE REDUCTION TECHNOLOGY
George W. Brooks 804-827-2042
(501-04-01; 743-65-11; 743-65-12)

The objective is to measure and analyze parametric variations in directivity patterns, noise spectra, and acoustic power emanating from a supersonic model jet exhausting over a finite surface. Measurements of the sound field directivity patterns will be made in a free field environment on a large scale wing model with jets exhausting from small supersonic nozzles placed at various stations adjacent to the wing surface. The initial tests would involve cold flow at various supersonic pressure ratios including shock-free conditions. These tests would then be followed by studies involving heated jets in order to account for the effects of refraction due to temperature.

W74-70189 **743-34-21**
Lewis Research Center, Cleveland, Ohio.
AST POLLUTION REDUCTION TECHNOLOGY
Richard A. Rudey 216-433-6160
(501-04-02; 501-24-02; 501-24-18)

The objective is to minimize the amounts of pollutants being discharged by aircraft engines into the upper atmosphere, by improving combustor and/or augmentor designs and to determine the effects of these pollutants on the atmospheric environment of the stratosphere. Achieving low levels of exhaust emissions from high altitude aircraft, by improving combustion design principles, is needed in order to minimize any potential interaction of combustion products with the ambient atmosphere. The determination of the potential interactions and effects are needed to evaluate potential hazzards that may arise from operating large fleets of supersonic aircraft in the stratosphere. Ground tests are needed to identify the level and character of exhaust pollutants, the potential reductions possible through technology development, to provide data for development of jet dispersion models, and the chemical processes that can occur over a period of time. Flight tests are needed to validate the ground tests and the models developed to describe the interactions between pollutants and the upper atmosphere.

W74-70190 **743-34-22**
Lewis Research Center, Cleveland, Ohio.
AST STRATOSPHERIC EMISSION IMPACT
Richard A. Rudey 216-433-6160

An objective is to evaluate and develop techniques to analyze and describe the possible detrimental effects of aircraft exhaust emissions from fleets of supersonic aircraft on the natural stratosphere. An additional objective is to support the Stratospheric Jet/Wake Experiment currently being planned. Ground tests are needed to identify the engine exhaust pollutant character and level and the chemical processes that they may undergo with the natural environment over a period of time. Flight tests are needed to validate the ground tests and the developed analytical models of the upper atmosphere characteristics.

W74-70191 **743-34-22**
Langley Research Center, Langley Station, Va.
AST - STRATOSPHERIC EMISSION IMPACT
Eugene S. Love 703-827-2893
(502-23-56; 501-24-20)

The objective of this RTOP is to develop flight instrumentation to be used to measure trace constituents in stratospheric jet wakes and the effect of these constituents on ambient stratospheric constituents. This RTOP continues a program started in FY-73 under 501-24-20. A feasibility study under that program identified tunable laser instruments which are capable of measuring jet wake constituents with greater sensitivity than currently available in situ techniques. The approach of this program will be to build a breadboard model of a two-ended diode laser absorption system, field test this system, and qualify the system for tropospheric flight tests on NASA aircraft. Absorption measurements will be performed external to the aircraft as it penetrates the wake. Laboratory tests of a laser heterodyne radiometer will be performed in order to evaluate the heterodyne radiometer for remote constituent measurements in future flight tests.

W74-70192 **743-34-22**
Ames Research Center, Moffett Field, Calif.
AST - STRATOSPHERIC EMISSION IMPACT
Glen Goodwin 415-965-5065

Basic objective is to develop an understanding of the interaction of supersonic jet exhausts with the upper atmosphere to provide data which can be used to assess jet wake impact on the natural atmospheric composition. Detailed objectives are: determine composition of the jet wake and the perturbations (chemical, hydrodynamic) in the stratosphere caused by the

passage of supersonic aircraft in a specified air corridor, obtain an inventory of the natural trace gases occurring in the stratosphere between 10 and 25 km over a wide range of latitudes; and develop and apply advanced instrumentation including a photoionization mass spectrometer to measure-trace atmospheric constituents in the stratosphere. The Jet Wake Measurements Program will be accomplished in four phases. Phase 1 will provide data to evaluate the methods, feasibility, and value of conducting an airborne experiment. Phase 2 will provide flight plans, cost estimates, and study data so the value of flight experiments can be stated and recommendations made. Phase 3 will include flight experiments where chase aircraft intercept and measure components in the wake produced by source aircraft. Phase 4 evaluates and correlates data from all phases to meet the program objectives. An interferometer-spectrometer will be used on a YF-12 aircraft to obtain spectra in the 1.2 to 8 micron spectral band using the sun as illumination source to deduce the concentration of natural trace gases. A pumped mass spectrometer using an UV ion source will be developed and used to selectively measure NO, NO2 and NH3. Studies of advanced instruments using resonance fluorescence and IR scanning techniques will be made to provide remote sensing instruments for measuring atmospheric and wake trace constituents.

W74-70193 **743-34-31**
Lewis Research Center, Cleveland, Ohio.
AST INLET STABILITY SYSTEM
M. O. Dustin 216-433-6136

The objective is to demonstrate an improved inlet stability system for supersonic, mixed-compression inlets. The system will allow the inlet to operate at a higher pressure recovery with less inlet unstarts than the present inlet system. The development of a shock stability bleed system using mechanical relief valves will be accomplished in wind tunnel tests using a full-scale YF-12 inlet. If successful, the stability system will be evaluated in flight on the YF-12 aircraft.

W74-70194 **743-34-41**
Lewis Research Center, Cleveland, Ohio.
AST EXPERIMENTAL ENGINE STUDY
R. J. Weber 216-433-6273

Advances in propulsion system technology will be required to permit the development of a quiet, clean, economical, commercial supersonic transport. Contracts for the study of such airplanes will be let by Langley Research Center with other supporting work to be performed by LaRC, LeRC, ARC, FRC, and DOT. As part of this overall effort, LeRC will let contracts to study various types of propulsion systems that might be applied in the advanced aircraft. The studies will determine the desirable characteristics of the engines, assess the benefits of advanced technology, and identify the needs for future research. They also will be used to define the content of an experimental engine program.

W74-70195 **743-34-51**
Lewis Research Center, Cleveland, Ohio.
LOW NOISE ENGINE - UNIQUE COMPONENTS
M. A. Beheim 216-433-6374

The objective is to develop the technology applicable to unique components required for low noise engines. Initial emphasis will be directed to three areas: (1) high temperature composite materials for jet noise suppressors and fan blades, (2) nacelle design requirements for duct burning turbofan and variable cycle engines, and (3) inlet and nozzle technology for multiple engine nacelles. For the composite material research, silicon carbide reinforced superalloy sheet metal will be fabricated to evaluate its suitability as a material for noise suppressors and aft portions of the engine and nozzle. Boron/aluminum metal matrix composite technology will be developed for use in fan blade fabrication. Study contracts will be awarded to engine/airframe design teams to examine the nacelle design requirements for a duct burning turbofan engine and for each of the two leading variable bypass engine concepts. Current activities related to inlet and nozzle research for single engine nacelles will be extended to include those concepts required for multiple engine nacelle installations.

W74-70196 **743-36-01**
Ames Research Center, Moffett Field, Calif.
STABILITY AND CONTROL PREDICTION OF FLEXIBLE AIRCRAFT
Edward W. Perkins 415-965-5851
(766-72-02)

The aeroelastic deflections experienced by large supersonic aircraft both in steady state and maneuvering (perturbed) flight have a major impact upon performance, stability, control, and the internal loads arising from such deflections. A major objective of this research is to develop improved analytical methods and to incorporate such improvements in the FLEXSTAB system of computer programs for calculating stability and control of flexible aircraft. Both longitudinal and lateral-directional motions are included. Modifications are planned that will provide improved lateral-directional results, more complete loads information, efforts of active controls, and improved representation of nonlinear aerodynamics. As modifications are made, the FLEXSTAB program will be validated by comparing computed results with experimental measurements from both flight and wind tunnel tests.

W74-70197 **743-36-02**
Langley Research Center, Langley Station, Va.
AST - DEVELOPMENT OF THEORETICAL FLIGHT CONTROL CONCEPTS
R. E. Bower 703-827-3285

Certain factors important to the achievement of economically viable AST require configurations, constructions, and modes of operation that necessitate active control systems. These control systems must deal with reduced static stability, modal excitations, and envelope limiting as well as other functions. This RTOP addresses itself to the task of theoretical study of the control concepts most effective in addressing these AST vehicle functions, and to related matters in control system design.

W74-70198 **743-36-03**
Langley Research Center, Langley Station, Va.
AST AERODYNAMIC STABILITY AND CONTROL
R. E. Bower 703-827-3285
(743-65-01; 743-32-12; 743-65-21; 743-36-13; 743-36-04)

The objective of this program is to provide a data base for selection and sizing of aerodynamic control surfaces and methodology for prediction of external aerodynamic loads due to propulsion system failure at supersonic speeds. The approach will be to design and construct wind tunnel models of candidate configurations under contract for tests in NASA facilities at subsonic, transonic, and supersonic speeds to determine the effectiveness, hinge moments, and associated characteristics of conventional trailing edge control surfaces and unconventional controls aimed at aeroelastic compatibility and active control applications. A theoretical procedure will be developed under contract to predict air loads on the airframe surfaces due to propulsion system failure. Wind tunnel tests will be made at supersonic speeds to validate the theory.

W74-70199 **743-36-04**
Langley Research Center, Langley Station, Va.
AST WIND TUNNEL TECHNIQUES FOR ACTIVE CONTROLS
George W. Brooks 703-827-2042

The objectives of this program are to establish the feasibility of wind tunnel simulation of advanced active control concepts; to develop modeling and testing techniques for elastic mode suppression studies, that is, gust load alleviation, ride quality improvement, and flutter suppression; and to define expected accuracies in extrapolating the wind tunnel data to full scale values. Work planned under this task is a continuation and extension of current studies using an existing modified supersonic transport planform semi-span model wing and a cable mounted B-52 model. The delta wing model can be considered similar to that of an SST and will be used to develop flutter suppression modeling technology. A later model generally typical of an advanced supersonic transport wing would be studied to measure the effectiveness of a flutter suppression integrated active control system. The wind tunnel studies will be conducted in-house with contract support for system design and evaluation. Related

activities are conducted by the U.S. Air Force Flight Dynamics Laboratory and a portion of this program is being conducted in cooperation with USAFFDL.

W74-70200 **743-36-11**
Ames Research Center, Moffett Field, Calif.
AST-HANDLING QUALITIES CRITERIA FOR ACT-CONFIGURED ADVANCED SUPERSONIC AIRCRAFT
Leonard Roberts 415-965-5066
(501-26-02)

Studies on the Ames piloted motion simulators and a parallel analytical effort will be directed toward the development of quantitative criteria for ACT-configured advanced supersonic airplanes. The initial simulations will use available mathematical models of large supersonic aircraft, and will be supported by analysis and trade-off studies. Stability and operating procedures will be systematically varied and the stability augmentation and control required to cope with each level of stability determined. Both longitudinal and lateral characteristics will be considered, and the operating procedures required for noise abatement will be included. Results will be utilized in a contractual investigation to determine performance gains to be realized through configuration changes that employ active controls. Prospective new designs will be investigated in later program phases. Additional piloted simulator studies will be directed toward the influence that the structural flexibility will have on the ability of the pilot to control the airplane safely and toward the development of criteria for cockpit motion. A related in-house effort will be continued to develop airworthiness standards for supersonic transport aircraft and flight-test procedures for demonstrating compliance. This will be accomplished by piloted simulation studies conducted jointly by FAA and NASA.

W74-70201 **743-36-12**
Ames Research Center, Moffett Field, Calif.
AST CONTROL SYSTEM MECHANIZATION TECHNIQUES
Bradford H. Wick 415-965-5567

The objective is to: (1) develop alternative redundant surface actuation systems required for an active control configured supersonic transport aircraft; (2) explore system failure modes, ability of the crew to react to these failures, and the resultant effect on control system design requirements. Piloted motion simulator studies will be conducted to investigate the acceptability or various redundancy concepts needed for active controls in terms of control stability and responses in normal operation, and the ability of the pilot to detect and react to failure in the systems. These studies will use math models and hardware mechanizations (mini-rigs) of the candidate control systems, developed on the basis of contracted efforts by Boeing extending current Phase 1 and Phase 2 SST technology follow-on efforts sponsored by DOT, a study of alternate concepts by another contractor, and data from in-house studies at LaRC and ARC. Emphasis will be placed on actuator systems and structural support compliances scaled to the size of the SST class of airplane. This effort is complementary to RTOP 743-36-11 and will be carried out jointly with that RTOP.

W74-70202 **743-36-21**
Flight Research Center, Edwards, Calif.
FLIGHT RESEARCH ON LAMS CONTROL SYSTEMS
F. W. Cazier, Jr. 805-258-3311

The objective of this effort is to advance the technology for improving fatigue life, reducing flight loads, and improving ride qualities of large flexible vehicles. Automatic closed-loop control system techniques will be used to actively reduce the dynamic response of the total airframe to turbulence and other dynamic disturbances. A system will be designed and installed on the YF-12 airplane and flight tested throughout its subsonic and supersonic flight envelope. Instrumentation will be installed to measure loads and aircraft response. The flight program will provide design, operational, and service experience and will allow pilot evaluation of system performance.

W74-70203 **743-36-22**
Flight Research Center, Edwards, Calif.
AST - COOPERATIVE AUTOPILOT/SAS/PROPULSION CONTROL SYSTEM
G. J. Matranga 805-258-3311
(501-24-21)

Significant airplane flight path disturbances, attributable to the propulsion system, have been observed on the XB-70 and YF-12 airplanes at high speed. This RTOP is developing wind tunnel and analytical techniques for predicting airframe/propulsion system interactions of advanced supersonic aircraft and determining the feasibility and benefits of a cooperative autopilot/SAS/propulsion control system. This goal is being pursued by conducting simulator and analytical studies to determine the possible benefits to be derived through the use of such an integrated control system on the YF-12. Contracts are being let for the design, construction, and installation of such a system on the YF-12. Flight tests are planned to verify the benefits that can be obtained by such a system in an operational environment.

W74-70204 **743-65-01**
Langley Research Center, Langley Station, Va.
ADVANCED SUPERSONIC TECHNOLOGY: AERODYNAMIC PERFORMANCE - SYSTEMS STUDIES
R. E. Bower 703-827-3285

This RTOP covers the conduct of AST systems studies which will identify and assess the impact of new technologies applicable to future supersonic commercial aircraft. It is necessary to determine how these advancements can be successfully integrated into a design for a supersonic cruise aircraft. In particular, to investigate such areas as subsonic/supersonic performance, economics, safety, comfort, and those characteristics such as noise, pollution, etc, which interact with the social community. Contractual system studies will evaluate advanced supersonic technology in aerodynamics/configurations, propulsion, structures, materials, flight controls, and avionics. The impact of these new technologies will develop into a base of knowledge for design. These studies will define the state of readiness and evaluate high risk and recommend the actions necessary to minimize these risk areas. This work will be supported and complemented by program elements under Langley Research Center, Lewis Research Center, Ames Research Center, Flight Research Center, and the Department of Defense (DOT-FAA); covering fundamental aerodynamic and structural technology, propulsion inlet and nozzle studies, flight research support of programs and inputs from SST technical follow-on program of the DOT-FAA. Contracts shall provide a level of effort over a period of two (2) years with three (3) or less contractors.

W74-70205 **743-65-11**
Ames Research Center, Moffett Field, Calif.
ADVANCED SUPERSONIC TECHNOLOGY - OPTIMUM DESIGN/CCV
H. M. Drake 415-965-5851
(743-65-12; 743-65-21)

To provide information in areas where experience has shown that design knowledge for advanced supersonic transport aircraft is incomplete. The potential performance gains to be realized by relaxing conventional aerodynamic stability requirements (CCV concepts) will be assessed by theoretical studies and wind tunnel tests. To improve the efficiency of optimization techniques, new programs are being developed that incorporate certain features of the vehicle synthesis problem directly into the optimization algorithm. A study of selected critical technology areas is to be made to provide feasibility information for use in defining alternate AST configurations. To develop a computer program for automatic digital and graphical description of the interior layout of transport aircraft and couple the programs to the aircraft synthesis program. Powered large-scale models will be tested to study the variations of noise emission with engine placement. Correlations of theoretical and experimental results from wind tunnel tests and flight tests will be made.

W74-70206 **743-65-12**
Langley Research Center, Langley Station, Va.
AST AERODYNAMICS AND PERFORMANCE (CONCEPTS)
R. E. Bower 703-827-3285
(743-65-21; 743-65-11; 743-65-21)

The objective of this program is to develop advanced

supersonic cruise vehicle concepts to support the development of adequate control surface and control criteria to apply to these concepts and to provide a source of experimental data from which these concepts can be optimized. The fully integrated concepts will serve as baseline configurations for technology development programs in structures, aerodynamics, propulsion, and flight controls. The approach to be taken is to study past concept development work in the supersonic transport program and to search for improved concepts that may become possible due to technology advances in propulsion, structures, stability and control, aerodynamics, avionics, systems, aeroelasticity, etc., as well as related changes in criteria. The concepts which evolve from these studies will be subjected to extensive analytic and experimental investigations. Representative models will be constructed to determine detailed aerodynamic characteristics, pressure distributions, and to investigate the problems of control surface and propulsion system integration. Multiple solutions to a given aerodynamic problem will be sought in order to afford the designer options in the total job of configuration integration and optimization. Complete fixed-wing and variable-sweep concepts which offer promise of meeting the demanding requirements of future SST missions will be synthesized and studied.

W74-70207 **743-65-21**
Langley Research Center, Langley Station, Va.
AST AERODYNAMICS AND PERFORMANCE (THEORY)
R. E. Bower 703-827-3285
(501-06-01; 743-65-21)

The objective of this program is to develop and validate methods for use in predicting the overall aerodynamic characteristics and detailed load distributions, for various design and off-design conditions, of advanced supersonic aircraft configurations. The purpose also is to develop more adequate means to assess the detailed aerodynamic interference between airframe and propulsion system inlet-nacelle installation, and in particular for airframe/engine combinations which employ two-dimensional inlets and non-axisymmetric nacelles. Theoretical methods will be developed through contract and in-house studies and then evaluated with in-house tests of representative models of advanced supersonic aircraft. The theoretical approach will utilize various finite-element techniques along with automated aircraft geometry description programs. The analytic studies will involve improvements to existing linearized theory-area rule methods and to the inclusion of local Mach number effects to allow prediction of detailed surface loadings and flow fields of complete configurations. The off-design aerodynamic problems and critical design load problems will be approached by including leading-edge separation and reattachment in finite-element lifting surface theories. Experimental data will be obtained at supersonic, transonic, and subsonic speeds for comparison with the theories.

W74-70208 **743-65-21**
Ames Research Center, Moffett Field, Calif.
AST AERODYNAMICS AND PERFORMANCE (THEORY)
Leonard Roberts 415-965-5033

The research performed under this RTOP is to develop and evaluate aerodynamic theories for use in predicting the high-lift characteristics of advanced supersonic technology aircraft, including wing-body interference, propulsive flow effects, airframe acoustic shielding effects, and ground effects. The overall objective is to provide the theoretical technology for design of advanced supersonic transport aircraft having acceptable aerodynamic and acoustic characteristics during landing, take off, and subsonic flight operations.

W74-70209 **743-65-31**
Ames Research Center, Moffett Field, Calif.
SONIC BOOM
Edward W. Perkins 415-965-5851
(501-04-01)

New and advanced theoretical methods will be used to establish climb and cruise flight profiles which will produce acceptable levels of sonic boom pressures on the ground for supersonic configurations. The results from these studies will be used to design vehicles which generate minimum sonic boom intensities. The configurations will be tested in the wind tunnel and the data compared with analytical results using newly developed methods for analyzing and interpreting very-near-field pressure signatures in terms of predicted ground overpressure characteristics in flight.

W74-70210 **743-65-31**
Langley Research Center, Langley Station, Va.
SONIC BOOM
R. E. Bower 703-827-3285

The technical objectives are to: (1) provide new and improved theories for calculating the magnitude and physical extent of sonic-boom overpressures generated in climb and cruise flight; (2) to develop design methods for use in defining minimum boom configuration concepts; and (3) to develop configurations and flight trajectories which will minimize sonic boom overpressures. A coordinated program of analytic studies and wind tunnel experimentation will be employed to develop improved methods for prediction, and to provide definition of configuration requirements for minimization. Both in-house and contract studies will establish the feasibility of design concepts which appear to offer sonic boom benefits. Focus phenomena and atmospheric variability will be studied with the aid of experimental data from previous flight tests and from a planned rocket sled test program.

W74-70211 **739-70-01**
Lewis Research Center, Cleveland, Ohio.
JT8D RETROFIT DEMONSTRATION
A. A. Medeiros 216-433-6317

The objectives are to: (1) develop modifications for the JT8D engine that can be produced as retrofit kits, (2) develop nacelles with acoustic treatment for the modified engines, and (3) demonstrate airplane performance and reduced noise levels by flight demonstration. The JT8D engine will be modified by replacing the existing two-stage fan with a larger diameter single-stage fan employing wide spacing between the vanes and rotor. The core engine pressure and flow will be maintained by two booster stages in front of the compressor. The fan turbine last stage rotor blade will be recambered. These changes will increase the engine thrust and lower the core jet velocity for the same cycle temperature. The lower jet velocity will result in decreased jet mixing noise. Acoustic treatment will be added to fan ducts and other acoustic devices will be considered to select the optimum nacelle. Installation studies and model tests in wind tunnels of the modified airplanes are in process. Nacelles will be fabricated. Engine components and engines will be ground tested. Engine/nacelles will be installed on the DC-9 and 727 airplanes and flight tests conducted.

W74-70212 **766-71-01**
Ames Research Center, Moffett Field, Calif.
C-8A AUGMENTOR WING PROOF-OF-CONCEPT FLIGHT PROGRAM
W. L. Cook 415-965-5486
(766-71-02; 768-83-01; 768-81-03)

An existing C-8A aircraft was modified to incorporate an augmentor-wing powered high lift device and jet engines for proof of concept testing takeoff and landing performance required for fan jet STOL transport aircraft, and to make available an aircraft for limited longterm flight research on the jet STOL type of aircraft. The modified aircraft has the capability of takeoff and landing at speeds of 60 to 65 knots required for a STOL balanced field length of 1500 feet. The aircraft has the performance and control characteristics required to allow flight investigations of takeoff and landing approach profiles and procedures for minimizing noise or approach time. It will also be used to further develop criteria for handling qualities, performance requirements, resolving operating problems, and air traffic operation. The program is a cooperative effort by NASA and the Canadian Government that has been underway since 1965. The program encompasses analytical studies, wind tunnel investigations, ground based simulation studies, design feasibility studies, detail design and modification of aircraft, and flight investigations. The program will provide much needed information for the designers of fan jet STOL aircraft which the NASA short-haul V/STOL transport studies showed to be one of two V/STOL concepts that had

the lowest direct operating costs for 500 mile range commercial transports.

W74-70213 **766-71-02**
Ames Research Center, Moffett Field, Calif.
FLIGHT EXPERIMENT PROGRAM - AUGMENTOR WING JET STOL RESEARCH AIRCRAFT
Leonard Roberts 415-965-5066
(760-61-03; 766-71-01)

The primary objective is to perform flight experiments essential to the verification and refinements of propulsive lift jet STOL handling qualities design and certification criteria. These criteria are under development through analysis and ground-based piloted simulation under RTOP 760-61-03. The program will use the Augmentor Wing Jet STOL Research Aircraft (AWJSRA) to verify analysis and simulation. In addition, it will use in-flight simulation to provide a wide variation in parameters required to satisfy the generalized objective and to assist in planning the flight program for the AWJSRA. The AWJSRA flight program and the in-flight simulation will encompass basic STOL handling qualities, stability and command augmentation systems, flight director laws, and control integration with the results having application to handling qualities design criteria. Operational characteristics to be considered include flight path control authority, operating margins, maneuver capability, stability limitations and field length factors.

W74-70214 **766-72-01**
Flight Research Center, Edwards, Calif.
YF-12 FLIGHT OPERATIONS
G. J. Matranga 805-258-3311
(766-72-02)

The YF-12 type airplanes are the only airplanes in the free world which are capable of sustained Mach 3 flight. Major areas of research include the examination of the hot, flexible structure; dynamic inlet behavior; airframe/propulsion interaction; and general problems related to high speed and high altitude flight. In the structures area, thermocouples and strain gages have been installed in airplane 935. Ground calibrations will allow for the measurement of hot loads in flight. Flight results will be compared with NASTRAN predicted information. Dynamic inlet information obtained in flight will be compared with results from a 1/3 scale inlet model and a full scale inlet operated in the wind tunnel. Airframe/propulsion interaction flight information will be related to data predicted using a 1/12 scale airplane model. The airplanes will be used in support of numerous Advanced Supersonic Technology projects.

W74-70215 **766-72-02**
Flight Research Center, Edwards, Calif.
YF-12 DISCIPLINARY RESEARCH
J. D. Watts 805-258-3311

A closely coordinated flight and ground test program utilizing the YF-12 airplane is being carried out in parallel with an extensive wind tunnel and analytical program. The overall objective is to thoroughly evaluate the state-of-the-art of flight loads measurement, loads predictions including aeroelasticity and thermal effects, and structural analysis for flexible hot-structure aircraft. The major efforts in the program are: flight measurement of wing and fuselage loads and deflections, laboratory determination of temperature effects on loads and deflection measurements, 1/12 scale rigid YF-12 pressure model tests, an 8000 degree-of-freedom NASTRAN structural model of the aircraft, and a FLEXSTAB panelized aerodynamic model of the aircraft. Data from all these sources will be correlated in the final analysis. Predictability of steady-state supersonic inlet performance, inlet flow dynamics, and interactions of engine, inlet, and aircraft control systems are the major problems to be evaluated with the YF-12 airplane. The effort involves simulations, wind tunnel tests of a 1/12 scale airplane model, a 1/3 scale inlet model, and a full-scale inlet, and flight tests of the YF-12 propulsion system. Other research includes boundary layer experiments, base drag measurements, and aerothermodynamic tests performed in the Mach 3 flight--

W74-70216 **766-72-02**
Ames Research Center, Moffett Field, Calif.
YF-12-DISCIPLINARY RESEARCH
H. M. Drake 415-965-5851
(766-72-01)

The unique performance capabilities of the YF-12 airplane provides an opportunity to obtain heretofore unavailable flight data. These data are invaluable for the assessment of theoretical and empirical prediction methods, and an evaluation of wind tunnel tests of that airplane or its components. Comprehensive wind tunnel tests will be made in the areas of: (1) the engine-air inlet and internal flow system; (2) the effects on the aircraft aerodynamics produced by the various modes of operation of the propulsion system; and (3) aeroelastic effects on the aircraft stability characteristics. Flight tests will be conducted by the NASA Flight Research Center for correlation with the wind tunnel results, and with predictions based purely on aerodynamic theory.

W74-70217 **766-72-02**
Lewis Research Center, Cleveland, Ohio.
YF-12 PROPULSION RESEARCH
M. O. Dustin 216-433-6136
(501-24-21)

The objectives are: (1) to evaluate the capability of currently available computer simulation techniques to determine dynamic characteristics of a high Mach number aircraft; (2) to investigate advanced concepts for improving inlet stability margins; (3) to study the existing aircraft control systems and investigate alternate control methods which can both improve the propulsion system performance and minimize propulsion system-airframe interaction; and (4) to evaluate a shock stability system for the YF-12 inlet, first in the 10x10 and then in flight.

W74-70218 **766-74-01**
Langley Research Center, Langley Station, Va.
COMPOSITE MATERIALS APPLICATION TO C-130 CENTER WING STRUCTURE
George W. Brooks 703-827-2042
(501-22-03)

The objective of this program is to obtain longtime flight service performance of filamentary composite materials in the center wing box of C-130 aircraft. The objective will be achieved through a systematic program as follows: (1) conduct advanced development study to provide design allowables, manufacturing and process methods, and required analysis methods; (2) perform detailed design; (3) fabricate three composite-reinforced aluminum alloy wing boxes; (4) perform ground test on one full-scale box (fatigue and strength); (5) install wing boxes in two C-130 aircraft, and deliver aircraft to Air Force; and (6) perform periodic monitoring to establish performance of wing boxes. The results of this flight service program will provide meaningful data on the performance of composite materials in a primary structure in the flight environment. Results will also be obtained on design, manufacturing, and processing methods, nondestructive evaluation, and field inspection procedures heretofore unavailable on large scale composite-reinforced primary aircraft structures. The program will provide confidence needed before commitments are made to future applications in aircraft structures.

W74-70219 **766-75-01**
Flight Research Center, Edwards, Calif.
DIGITAL FLY-BY-WIRE FLIGHT EXPERIMENT
C. R. Jarvis 805-258-3311

The overall objective of this joint effort with LaRC is to provide the technology necessary for the implementation of advanced reliable digital fly-by-wire systems in future aircraft. The program is to be carried out in accordance with the schedules and resources identified by the digital fly-by-wire project plan submitted in February 1973 and formally approved in March 1973. In Phase 1, currently underway, flight tests are being conducted on an F-8C aircraft employing a single channel digital system which was developed using Apollo hardware, to establish the feasibility of digital fly-by-wire systems. These tests will investigate handling qualities, aircraft response, design techniques, and filter and gain variations during low-speed and cruise flight. In Phase 2, through a cooperative effort with LaRC, a multichannel all digital system is to be developed and flight tested in the F-8C aircraft. A dual channel system will be developed and

flight tested initially, which will later be expanded to a three or four channel configuration. Provisions will be made to evaluate, in flight, advanced control laws being developed by LaRC in accordance with the project plan schedule.

W74-70220 **766-75-02**
Langley Research Center, Langley Station, Va.
DIGITAL FLY-BY-WIRE FLIGHT CONTROL SYSTEM RESEARCH AND DEVELOPMENT
G. B. Graves 703-827-3745
(501-23-31; 501-23-32; 766-75-01)

The objective is to provide a design base for reliable, cost-effective digital fly-by-wire flight control systems for commercial and military aircraft applications. A cooperative program of theoretical and experimental research, and demonstration in DFWB flight control will be carried out by the Flight Research Center and the Langley Research Center. As presently conceived this program has two phases, both phases of which involve the use of the F-8C aircraft as a test vehicle. The Phase 1 program which is an initial demonstration and exploration program uses Apollo hardware. This program is currently under way at FRC, and responsibility for this program lies largely with FRC. The Phase 2 program has two parts: the first involves simply the replacement of the Apollo hardware with a dual computer-sensor system for use in the exploration of various forms of advanced control law software; and the second involves the use of a fully redundant computer and flight control system. The first part of Phase 2 would be carried out as an experimental program with the present analog flight control system as a backup for safety. The second part of Phase 2 would involve a transition to the fully redundant flight control system by removal of the analog backup control system at some point in time. Experimentation in control law software would continue during this last portion of Phase 2. The Phase 2 program in addition to experimentation in advanced control laws will involve researches into digital actuators and sensor systems that will benefit the flight control task with a view of providing improved systems to be incorporated into the last portions of the Phase 2 program.

W74-70221 **766-76-01**
Flight Research Center, Edwards, Calif.
TRANSONIC AIRCRAFT TECHNOLOGY (TACT)
Weneth D. Painter 805-258-3311

The objectives of this effort are to: (1) demonstrate the supercritical wing improved transonic drag rise and lift levels for buffet onset shown in wind-tunnel investigation, and (2) establish the desired level of confidence in prediction of supercritical wing characteristics for future applications. This is a joint NASA/USAF program being conducted in accordance with a Memorandum of Understanding dated 16 June 1971. The supercritical wing and associated parts were provided by Convair Division of General Dynamics under Air Force Contract AF 33615-71C-1912. The left hand wing was structurally proof tested at the AFFDL Wright-Patterson AFB. NASA (FRC) will supply and install the basic instrumentation as well as perform the aircraft modification and wing installation. NASA FRC will also be responsible for the flight test and total program management beginning in FY-74.

W74-70222 **766-76-02**
Ames Research Center, Moffett Field, Calif.
F-111 TACT RESEARCH AIRCRAFT
H. M. Drake 415-965-5851
(501-26-04)

The overall objective of the Transonic Aircraft Technology (TACT) Program is to provide a proof-of-concept research flight demonstration of recent advances in supercritical wing technology applied to a maneuvering fighter configuration with variable sweep capability. Specifically, the effort at the Ames Research Center will be to provide thorough wind tunnel investigations as the basis for prediction of aerodynamic performance, stability, control, buffeting characteristics, and structural loads of the TACT airplane. Correlation of the predicted characteristics based on the wind tunnel results with full-scale flight test data is a further major objective.

W74-70223 **766-76-03**
Langley Research Center, Langley Station, Va.
TRANSONIC AIRCRAFT TECHNOLOGY (TACT)
T. G. Ayers 703-827-2631
(766-76-01; 766-76-02)

The overall objective of the Transonic Aircraft Technology (TACT) program is to provide a research flight demonstration of recent advances in supercritical wing technology as applied to a variable wing sweep maneuvering fighter configuration. The effort at the Langley Research Center will be to provide, through wind tunnel tests, the nozzle thrust-minus-drag and fuselage afterbody drag coefficients for use in correcting static aerodynamic data to full scale airplane values for various engine power settings. The Langley effort will also provide technical assistance for the correlation and analysis of the wind tunnel and flight aerodynamic data.

W74-70224 **745-77-01**
Langley Research Center, Langley Station, Va.
ROTOR SYSTEMS RESEARCH AIRCRAFT
R. E. Bower 703-827-3285

The Rotor Systems Research Aircraft (RSRA) objective is to develop and bring into operation two versatile flight research aircraft to provide economical rotorcraft research capability in the real and dynamic environment of flight. These research aircraft will provide the research capabilities that cannot be duplicated in ground based facilities and that have previously been restricted because of the expense of specialized vehicles. The versatility of the Rotor Systems Research Aircraft will provide: (1) economical flight research of a wide variety of promising new rotor concepts, and (2) real-world verification of rotorcraft supporting technology offering potential solutions to existing or anticipated problem areas. This is a joint program with the Army, in accordance with the Memorandum of Understanding between NASA and the Army dated November 1, 1971. The program will be managed through a joint Project Office in accordance with the Project Plan which was approved on February 23, 1973. This RTOP is also to provide Langley Research Center technical support of rotorcraft technology and of the Ames Tilt Rotor Project.

W74-70225 **744-78-01**
Ames Research Center, Moffett Field, Calif.
V/STOL TILT ROTOR RESEARCH AIRCRAFT PROGRAM
W. L. Cook 415-965-5486
(760-63-03; 760-63-04)

The technical objectives are to design, develop, and bring into operation two tilt rotor research aircraft to provide flight research vehicles for proof-of-concept of the tilt rotor V/STOL concept, and operations flight research for potential military and civil missions. The flight research program will include: (1) experimental exploration through flight research of current technology of interest to industry for their consideration for development of useful, quiet, easily maintainable commercial or military V/STOL tilt rotor aircraft, particularly by verifying rotor/pylon/wing dynamic stability and aircraft performance over the entire operational envelope; (2) establishment of safe operating envelope and initial assessment of the handling qualities for use in follow-on advanced flight research, (3) investigation of tilt rotor gust sensitivity, and (4) investigation of tilt rotor disc loading and tip speed on downwash and noise, and the impact on hover mode operations. This is a joint program with the Army, in accordance with the Memorandum of Understanding with the Army dated November 1, 1971. The program will be managed through a joint Army/NASA Project Office in accordance with an approved Project Plan for development of two V/STOL Tilt Rotor Research Aircraft. Two contractors were selected (Bell Helicopter Co. and Boeing Vertol Co.) on 10-20-72 to participate for a three month period in competitive detail design analysis and program planning resulting---

W74-70226 **768-80-01**
Ames Research Center, Moffett Field, Calif.
NOISE REDUCTION FLIGHT PROCEDURES EXPERIMENTS
Bradford H. Wick 415-965-5567
(501-38-13)

This program will further develop and evaluate the feasibility of using operational procedures as a means of reducing aircraft noise. The first phase of this program is aimed at determining the feasibility of using two-segment approaches for aircraft noise abatement during routine scheduled service. The program is being conducted with United Air Lines and calls for separate flight evaluations using a Boeing 727-200 and a McDonnell-Douglas DC-8-61, each equipped with different two-segment avionics. The 727 has a two-segment approach system and the DC-8 will be equipped with an area navigation system modified to include the two-segment approach mode. Both sets of avionics are being built by Collins Radio Company. The results of these tests will then be extrapolated to other aircraft in current fleet inventories. Additional avionics will be made available to other air carriers for further evaluation of the two-segment approach in scheduled service. The second phase of the program will be directed towards determining the noise reduction potential of procedures such as the decelerating or curved approach. The relationship between aerodynamic and propulsive noise for these other techniques will be assessed with the objective of defining a procedure that will result in further noise abatement.

W74-70227 **768-81-01**
Langley Research Center, Langley Station, Va.
VEHICLE DEPENDENT ASPECTS OF TERMINAL AREA GUIDANCE AND CONTROL
G. B. Graves 703-827-3745
(768-81-02; 768-83-04)

The objective is to determine the aircraft performance and control system characteristics needed for efficient operation in terminal areas with advanced air-traffic management concepts and improved avionics. Emphasis is placed on vehicle dependent aspects such as maneuver capability, speed control, turbulence response, ride quality, flight path control, and the relation of control characteristics to avionic systems. CTOL, STOL, and VTOL aircraft will be considered. Concurrent Langley efforts on terminal area operating practices, handling qualities, control configured vehicles, and avionics such as wide area navigation systems, digital flight control systems, and displays for terminal area and final approach to landing are important considerations in this work. Modeling and simulation capabilities will be used to examine the performance of various classes of aircraft with selected terminal area traffic and airspace constraints, control concepts, avionic systems, and the ground based elements of air-traffic navigation and control systems. Aircraft and airborne systems characteristics will be related to control concepts, safety considerations, traffic density, delays, noise, and economics. Aerodynamic and control simulations will be utilized to evaluate aircraft performance limitations. Parametric sensitivity and tradeoff studies between aircraft performance characteristics and ground and airborne electronic system capabilities will be made. Analyses and simulation studies will be closely related to the airborne systems technology effort under RTOP 768-81-02.

W74-70228 **768-81-02**
Langley Research Center, Langley Station, Va.
TERMINAL CONFIGURED VEHICLE PROGRAM
G. B. Graves 703-827-3745
(768-81-01; 768-83-04; 791-93-51)

The objectives of this program are to develop and demonstrate technology which will: (1) allow reductions in delays caused by adverse weather, thereby increasing schedule reliability and allowing reconsideration of reserve fuel requirements; (2) allow increases in capacity of present airports; (3) allow for the reduction of noise signature and exposure in airport communities; and (4) improve the safety in both the terminal area and the landing phases of flight. Special attention will be given to avionic systems which take full advantage of advanced terminal area navigation systems and the microwave landing system being developed by FAA. The problems of approach and landing independent of weather, considering noise alleviation and a required increase in runway acceptance rate with minimum delays, are paramount in the air transport system. The airborne equipment and procedures, available for use with ground facilities, to attack these problems have only been examined in parts and pieces. It is urgent that a coherent program be developed which will directly address the problems of integrating aircraft pilot displays and controls in the advanced high density airport environment. Simulation and flight studies will be conducted at LRC, Wallops, and FAA facilities. The most advanced equipment will be operated in models of present and future airport environments to investigate reliability, digital techniques, automatics, displays, and procedures. Flight modes including terminal area descent, final approach, landing, and---

W74-70229 **768-81-09**
Wallops Station, Wallops Island, Va.
WALLOPS SUPPORT OF MLS FEASIBILITY DEMONSTRATION
G. E. Godwin 703-824-3411
(768-81-09)

The Microwave Landing System (MLS) is a civil/military aircraft approach and landing system which is being developed in a joint DOD/DOT/NASA program. Needs of the military and civil aviation, at domestic and foreign airports until at least the year 2000, are to be met by MLS. Development is being accomplished under a three step, five year plan. The steps are decribed as follows: Step 1 - technique analysis and control definition, Step 2 - development of feasibility demonstration models and feasibility demonstration, and Step 3 - development and evaluation of preproduction engineering prototypes. NASA, Wallops Station has been requested to serve as one of the test sites for the Step 2 - feasibility demonstration of the MLS, by the FAA, prime government agency responsible for the development of the MLS. The FAA NAFEC at Atlantic City, NJ will serve as the other feasibility demonstration site. This RTOP will cover the Wallops Station support of the feasibility demonstration portion of the MLS development.

W74-70230 **768-82-01**
Ames Research Center, Moffett Field, Calif.
VTOL OPERATING SYSTEMS EXPERIMENTS
Bradford H. Wick 415-965-5569
(768-83-03; 768-83-01)

Basic objectives include the attainment of VTOL guidance, navigation, and control, and flight management data that will be of value to industry and Government agencies in establishing the relationships between concepts, level of automation, design criteria, system performance, pilot requirements, and operational requirements. The approach will utilize three main types of research effort: analytical studies, piloted closed loop simulations, and flight experiments. Analytical studies will be carried out in-house and under contract. Piloted simulations will be carried out at ARC prior to initiation of flight tests. Flight experiments will be carried out using V/STOLAND, which is an integrated digital avionics system using state-of-the-art technology. After initial tests to conduct system verification and checkout, V/STOLAND will be installed in an advanced VTOL vehicle, having the requisite cruise speeds for rapid movement of people, to accomplish the required flight experiments. Variations in on-board systems will cover the range from simple manual systems to fully automatic approach and touchdown systems. Time constrained flight paths, steep curved, and decelerating approaches and the effects of winds will be investigated, with emphasis on transition and VTOL modes of operation. Several ground guidance systems will be considered for landing guidance (e.g., MODILES, MLS).

W74-70231 **768-82-02**
Langley Research Center, Langley Station, Va.
ROTARY WING VTOL OPERATING SYSTEMS EXPERIMENTS
G. B. Graves 703-827-3745
(501-23-11; 760-63-04; 760-63-05)

The program will encompass the investigation of operating systems and piloting techniques required for helicopter operations under all-weather conditions from downtown vertiports. The terminal air traffic and airspace requirements, the avionics system requirements for navigation, guidance, flight control, and displays for automated takeoffs, cruise, and landings will be defined. Flight vehicles, equipped with electronic display systems and advanced control concepts, will be utilized in flight experiments to define the degree of automation required for VTOL terminal area

operations, and to explore operating procedures and piloting techniques applicable to city-center helicopter operations requiring curved, decelerating approach trajectories. Simulator studies, modeled after the New York area and New York Airways helicopter operations, will investigate airspace and obstacle clearance requirements and operating procedures for utilizing state-of-the-art displays and guidance systems, including steep gradient MLS approaches. As part of the joint NASA/Army program, in which the CH-47 is being provided, NASA will participate in MIT research to study pilot cueing requirements for improved handling qualities and warning of critical envelope limits.

W74-70232 **768-82-03**
Ames Research Center, Moffett Field, Calif.
GUIDANCE NAVIGATION AND CONTROL FOR THE SEA CONTROL SHIP VTOL AIRCRAFT
Leonard Roberts 415-965-5066
(768-83-03; 768-83-01)

The objectives are to determine the navigation, guidance and control requirements and to develop an interim avionics system that will allow a VTOL aircraft to make precise approaches and landings on a pad (approx. 50 ft. square) onboard a Navy Sea Control Ship under a wide range of weather and sea conditions. The effort will be directed toward the use of fixed and moving base piloted simulators with realistic out-the-window visual scenes to define the navigation guidance and control requirements for an onboard avionics system that will cover the range from manual (back-up-mode) to fully automatic approach, hover and landing. From these requirements, a set of shipboard navigation aids and shipborne/airborne sensors be defined and evaluated. A V/STOLAND avionics system will be used with modifications incorporating the new navigation aids and onboard sensors. This system will be installed on an interim VTOL aircraft for flight test verification of the simulation results. The simulation work will be supported by both in-house and contractual analytical studies relying heavily on existing digital simulation software.

W74-70233 **768-83-01**
Ames Research Center, Moffett Field, Calif.
TECHNOLOGY FOR ADVANCED INTEGRATED AVIONICS FOR TERMINAL AREA FLIGHT EXPERIMENTS IN STOL AIRCRAFT
Bradford H. Wick 415-965-5567
(768-83-03; 768-83-02)

The objectives are to develop navigation, guidance, and control avionics for use in STOL flight experiments and for use in STOL validation flights for the new common-use civil/military Microwave Landing System (MLS). The potential advantages of STOL can be realized only with advanced avionics systems and associated operational procedures which exploit the capabilities of STOL for making steep ascents and descents, tight turns, and slow-speed approaches and landings within the constraints of proposed ATC systems. Performance and design requirements for a flexible avionics system which will operate in various manual and automatic modes will be defined to satisfy the objectives of STOL flight experiments and of STOL MLS validation flights. In particular, requirements will be based on the use of the developmental scanning beam system, MODILS, (and perhaps the MLS) provided by the FAA for use in the STOL flight experiments. The flexible avionics system referred to as STOLAND will be designed and developed and then installed in appropriate STOL aircraft and tested in flight. With the exception of MODILS/MLS, the flight tests will be conducted using standard instrumentation, tracking, data processing, and navigation aids. The detailed design and development of STOLAND, which will be performed by the contractor, will be supported by relatively complete fixed base and moving base simulations of the aircraft and avionics system at Ames Research Center.

W74-70234 **768-83-02**
Ames Research Center, Moffett Field, Calif.
MICROWAVE LANDING SYSTEM VALIDATION FOR STOL AIRCRAFT APPLICATIONS
Bradford H. Wick 415-965-5567
(768-83-01; 768-83-03; 768-81-02)

The overall objective is to support the user agencies and the FAA in the task of developing a common civil/military approach and landing system called the National Microwave Landing System (MLS). Specific objectives include criteria definition, development of validation procedures, development of simulation to support flight validation, and STOL flight validation of the prototype MLS. The basic approach is to conduct closely related analysis, simulation, field investigations, and flight tests to develop realistic validation criteria, and use these criteria, together with STOL operational procedures developed under other programs, to validate the prototype MLS for STOL. The field investigations and available data will be used to update and refine MLS simulation models, and flight tests will be conducted with available landing aids to evaluate validation procedures and to obtain data for MLS modeling improvements. Simulation and flight investigations will emphasize MLS performance for STOL terminal area navigation, and approach and landing guidance for CAT 3 operations. The validation of the prototpye MLS configuration K will be conducted with STOL aircraft equipped with a programmable digital avionics system referred to as STOLAND.

W74-70235 **768-83-03**
Ames Research Center, Moffett Field, Calif.
STOL OPERATING SYSTEMS EXPERIMENTS USING MODILS AND THE CIVIL/MILITARY MICROWAVE LANDING SYSTEM (MLS)
Bradford H. Wick 415-965-5066
(768-83-01)

Experiments will be conducted on navigation, guidance, control, and flight management systems for STOL aircraft using advanced airborne avionics and the new Civil/Military Microwave Landing System. The results will be used to evaluate system concepts, and define design criteria and operational procedures for STOL aircraft. This program is part of the Joint DOT/NASA Operating Systems Experiments Program. Investigations will be conducted encompassing analyses, simulation, flight experiments, and supporting studies. The operational procedures criteria developed in this RTOP will be used for STOL aircraft operations *in terminal area effectiveness investigations. The criteria for* terminal area effectiveness previously developed will be used to select areas for investigation for this RTOP. These investigations will emphasize the terminal area navigation, guidance, control, and flight management problems which must be solved to take maximum advantage of STOL capabilities for making steep ascents and descents, tight turns, and slow speed approaches and landings. The flight experiments will be conducted using a flexible research avionics system, referred to as STOLAND, in conjunction with appropriate STOL aircraft. The complete research system comprises STOL aircraft, avionics, instrumentation, and the following navigation aids: VOR/DME, Tacan, and a scanning beam landing guidance system to be provided by the FAA.

W74-70236 **768-83-04**
Langley Research Center, Langley Station, Va.
STOL - AIR TRAFFIC CONTROL INTEGRATION STUDIES
G. B. Graves 703-827-3745
(768-81-01; 768-81-02)

This work is concerned with the problems of integrating STOL airplanes and the air traffic control (ATC) system in the terminal area. The objectives are to determine: (1) aircraft design and equipment requirements and operating procedures, and (2) airspace requirements and ATC equipment and handling procedures for efficient short-haul operations. Real-time simulation studies are being conducted by linking a STOL airplane simulator at Langley Research Center with the FAA's ATC simulator at Atlantic City. Studies will also be conducted by linking a STOL airplane in flight at Wallops Station with the ATC simulator.

W74-70237 **768-83-05**
Ames Research Center, Moffett Field, Calif.
INVESTIGATION OF THE USE OF STRAPDOWN INERTIAL SENSOR UNITS FOR THE INTEGRATION OF FLIGHT CONTROL, GUIDANCE AND NAVIGATION FUNCTIONS
Bradford H. Wick 415-965-5567
(768-83-01)

The objective is an in-flight investigation of specific current system technologies for a low-cost, highly reliable inertial guidance

and navigation concept which can be used as an integrated sensor package, and for use in improving guidance and navigation. This system will make full use of digital computer technology with the system elements regrouped for maximum performance and minimum complexity. It will be a multiple redundant system which fully utilizes an aircraft control computer for navigation, guidance and flight control. A candidate system is being developed by MIT-CSDL which will replace the standard set of inertial sensors with a multiple redundant strapdown inertial reference unit (SIRU). There are four tasks in this program. Task 1 is the establishment of requirements, development of technology, and identification of deficiencies for rectification. Task 2 is the identification and projection of performance and system requirements through computer analysis for the MIT-CSDL advanced inertial sensor systems. Task 3 comprises the investigation of this system through a comprehensive simulation, laboratory, and flight test program to confirm and refine the SIRU performance. Task 4 is the development of aided inertial Kalman filters for the MIT dodecahedron low cost SIRU through computer and motion simulation studies and flight tests.

W74-70238 **768-83-06**
Ames Research Center, Moffett Field, Calif.
TERMINAL AREA EFFECTIVENESS - OPTIMIZATION OF FLIGHT PROCEDURES OF SHORT HAUL TRANSPORT AIRCRAFT
Leonard Roberts 415-965-5000
(768-83-03; 501-03-11)

The objective of the research is to determine criteria for and gain pilot acceptance of flight procedures that optimize the terminal area effectiveness of future short haul transport aircraft. The criteria for flight precedures, which will be developed for specific vehicle and terminal area configurations, will minimize a weighted function of the noise and pollution impact, the airspace usage, delays and operating costs. Various short haul transport aircraft configurations will be studied, including RTOL, VTOL, advanced rotorcraft and powered lift STOL vehicles. The results of this study, together with those of RTOP 791-93-XX, which will develop terminal area models and perform general system studies of the terminal area effectiveness, will provide the Government with a rational basis for directing its advanced aircraft technology programs. The objective of this study will be achieved by means of a unique iterative technique involving the use of ARC's advanced moving base simulator together with a fast time flight path optimization algorithm. The piloted simulation will include a real time computer model of the ATC environment which will be used to evaluate the impact of future ATC systems on flight procedures. A computer graphics system will be installed in the simulation facility to permit improved representation of out-the-window scenes and efficient optimization of effectiveness measures. Realistic pilot constraints for selection of operational procedures will be obtained from RTOP 768-83-03. Conversely, the results of this study will influence the selection of flight experiments in RTOP 768-83-03.

W74-70239 **769-89-01**
Flight Research Center, Edwards, Calif.
QUIET PROPULSIVE LIFT TECHNOLOGY
D. A. Kier 805-258-3311

This RTOP covers FRC activities pertaining to the support of the joint Air Force/NASA AMST Program and activities supporting the Ames QPAT Office in the development of propulsive-lift aircraft technology. Technology development and multi-discipline flight experiments applicable to the AMST, the potential low-cost research airplane, and other QPLT activities will be proposed, developed and initiated, as appropriate, in the areas of general configuration, flight control systems, handling qualities, noise, flight dynamics, information displays and operating environment. The work will be accomplished in-house. Specific areas involved are: (1) participation on the AMST Joint Test Team, including flight test planning, developing NASA-proposed flight experiments, developing research instrumentation and data acquisition requirements, in-house data reduction and analysis, and information dissemination; (2) supporting Ames QPAT Office as required; (3) proposing, reviewing, developing, initiating and assisting other Centers in implementing flight experiments derived from the Short-Haul Flight Experiments Working Group on AMST and other potential aircraft; and (4) investigating control system requirements and operating environment for follow-on NASA-Lead AMST and low-cost research airplane programs. All of the above listed activities are essentially new efforts in FY-74.

W74-70240 **769-89-01**
Lewis Research Center, Cleveland, Ohio.
QUIET PROPULSIVE LIFT TECHNOLOGY
Raymond J. Rulis 216-433-6651

The objectives are: (1) to provide propulsion system support to the Ames Research Center's Quiet Propulsive-Lift Aircraft Technology (QPAT) Office in the development and conduct of a quiet propulsive-lift flight research program; and (2) to participate in the definition and conduct of multidiscipline flight experiments in appropriate areas including noise, propulsion/flight control system integration, information displays, and propulsion systems.

W74-70241 **769-89-02**
Ames Research Center, Moffett Field, Calif.
QUIET PROPULSIVE LIFT TECHNOLOGY
Leonard Roberts 415-965-5687
(760-61-02)

This RTOP covers the activities of the Quiet Propulsive-Lift Aircraft Technology (QPAT) Office, insofar as they relate to: assistance provided by the office for the planning and advocacy of the OAST Short-Haul Transport Technology Program; the conduct of interdisciplinary technology studies evaluating systems integration aspects of quiet propulsive-lift technology; participation by NASA in the Air Force AMST program and subsequent NASA use of those aircraft; and the definition of NASA's quiet propulsive-lift flight research needs, including investigation of research aircraft designs capable of meeting these needs. Support of the Short-Haul Transport Technology Program will be provided primarily through assistance in developing the Program Plan for that activity. Technology studies will be focused on system evaluation with emphasis on propulsion system installation and integration effects, particularly those which interact with the airframe and basic configuration aerodynamics. Participation in the AMST program includes joint planning with the Air Force of the flight test program, arrangements for the provision of special instrumentation or modifications to the aircraft, including contracted effort in wind tunnel and simulator facilities, and the conduct of additional analyses and tests in support of NASA's unique flight test requirements for the AMST. The capabilities of various low cost research aircraft to meet NASA's flight research objectives will be evaluated, considering that a portion of these objectives are met by the AMST and the C-8, and these evaluations will include analyses, aircraft design, and limited wind tunnel and simulator design verification activity.

Space Research and Technology Base

W74-70242 **502-01-01**
Ames Research Center, Moffett Field, Calif.
SURFACE PHYSICS AND CHEMISTRY
Glen Goodwin 415-965-5065

Studies will be initiated to obtain an increased understanding of the chemical, physical, and electronic properties of surfaces and, thereby, take maximum advantage of the surface-controlled properties of materials. These studies range from describing the changes in surface properties that result when foreign particles (atoms, molecules) interact with solid surfaces to the study of the growth characteristics of thin films and to the nature of composite interfaces. In addition, a study will be initiated to define the effects of the service environments on the physical, mechanical, and chemical behavior of metals and metal surfaces. This study will specifically explore the corrosive nature of various liquid fuels on container materials. Experimental studies will involve in-situ high resolution electron microscopy of thin film nucleation and growth phenomena in ultra-high vacuum under well controlled experimental conditions. The LEED/Auger/work function/ thermal desorption studies of the interaction of metal vapors and gaseous

species with metal and graphite surfaces will continue, and, an Auger-microprobe capability will be developed. The effects of fuels on various alloys will be assessed by the following approaches: Static metal coupon-fuel corrosion tests to determine corrosion rates and reactivity; physical analysis to measure film formation, passivation effects, and hydrogen diffusion; and plane-strain fracture tests to ascertain stress corrosion effects.

W74-70243 **502-01-02**
Lewis Research Center, Cleveland, Ohio.
PHYSICS AND CHEMISTRY OF SOLIDS
R. A. Lad 216-433-6601

The objectives are to: increase the base of understanding of the relationships between the electronic, atomic, molecular and microscopic structures of solids and their useful mechanical, structural and chemical properties, and provide information that will lead to advanced materials development in areas of particular importance to Lewis programs. Areas of focus will be: (1) those that are instrumental in controlling strength and fracture in metal matrix composites; (2) the chemistry and kinetics related to the hot corrosion of turbine components that results from oxidation and sulfidation; and (3) the chemical and electrochemical processes that are responsible for the operation of battery separators. Research on metal-matrix composites will cover: (1) theoretical and experimental study of the propagation of an elastic-plastic crack in a composite geometry in terms of dislocation mechanisms and current fracture theory; (2) theoretical study of the effects of alloying and impurity additions to the interface; and (3) experimental determination of shear strength and interface bond strength. Research on hot corrosion of turbine alloys will cover: (1) identification of chemical species involved - both on the surface and in the gas phase; (2) corrosion rate studies and thermochemical calculations to define a corrosion mechanism; and (3) surface analysis to study changes in composition during the incubation period. Research on battery separators will cover: (1) determination of chemical properties of separator components; and (2) study of ion transport mechanisms, inhibition of metal ion transport, surfactant properties of soluble organics and effect on zinc deposition.

W74-70244 **502-01-02**
Ames Research Center, Moffett Field, Calif.
PHYSICS AND CHEMISTRY OF SOLIDS
Glen Goodwin 415-965-5065

The objective is to exploit the unique capability of the Illiac IV computer to calculate reliable wave functions for ground and excited states of atoms, diatomic molecules, linear polyatomic molecules, and ultimately solid state matter. These wave functions will in turn be the basis for precision calculation of many basic properties of matter such as bond dissociation energies, radiation transition probabilities, dipole moments, auger transitions, chemical rate coefficients, and ultimately solid state properties such as electronic band gaps and conductivities. Computer codes for calculating wave functions using the parallel processing feature of the Illiac IV will be developed. These codes will be compared with the best available numerically computed wave functions, to assure that the coding is reliable, then they will be used to calculate larger expansions of these wave functions, which will be more precise than heretofore, and also wave functions for species which have not yet been computed. The lowest state of each symmetry type will be computed, and optical transition probabilities between these states will be evaluated. The work will concentrate on molecules such as HF, CO, CN, NO, N2, O2, C2, etc. which are of current interest with regard to planetary entry, heat shield ablation, upper atmosphere pollution, or gas lasers. Eventually the theory will be extended to include excited states of these species.

W74-70245 **502-01-03**
Langley Research Center, Langley Station, Va.
PROPERTIES OF MATERIALS FOR ELECTRONIC APPLICATION
Eugene S. Love 703-826-2893

Electronic and optical properties of materials are crucial for all solid-state devices. Of interest for these devices are semiconductor surface recombination rates, impurity type, stability to temperature, light and adsorbed gases, also the magnetic susceptibility, photochemical activity and sublimation energy of crystalline and amorphous insulators. The property studies covered by this RTOP are fundamental to improved solar cells, pollution-gas sensor, molecular reactions, and catalysis. Solar cells could have improved efficiency and high temperature power production by using GaAs with reduced surface recombination rate. In-house and contractual research involving surface properties and growth of thin layer crystals are advancing the state of solar cells. As an outgrowth from studies of organic photochromics, paramagnetic organic solids have recently been discovered and they suggest potential application as mm wavelength tunable maser amplifiers. Calculations on LiH in the gas and solid phase provide basic information on microscopic and thermodynamic properties of solids.

W74-70246 **502-01-03**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
PROPERTIES OF MATERIALS FOR ELECTRONIC APPLICATIONS
John W. Lucas 213-354-4530
(502-23-53; 502-33-93)

This is a program of experimental and theoretical research aimed at determining the basic relationships between electronic and defect structures of materials and their potentially useful electronic properties. The knowledge obtained will make possible the development of improved, or new, component concepts for NASA flight- and ground-based electronic systems. During the coming year, the research will encompass theoretical studies of electromagnetic radiation coupling with infrared-sensitive superconductors and experimental investigations of the interaction of electromagnetic radiation with superconductivity in thin-film quantum structures, defects in thin silicon-dioxide films ionization damage in silicon-dioxide films, radiation hardening and stability in dielectric films, and photoeffects in Schottky barriers on gallium arsenide and some III-V ternary compounds.

W74-70247 **502-01-03**
Marshall Space Flight Center, Huntsville, Ala.
PROPERTIES OF MATERIALS FOR ELECTRONIC APPLICATIONS
E. W. Urban 205-453-5130
(114-03-03)

A wide variety of superconducting devices have been proposed for space applications, including magnets and instrumentation. All are limited in utility by excessively low operating temperature requirements; magnets are additionally restricted by magnetic-thermal instabilities. It is important to seek techniques for increasing superconducting transition temperatures, to investigate new superconducting instrumentation concepts, and to improve the stability of magnetic materials. Theoretical and experimental studies are being made of the properties and preparation of known and new superconductors to determine those parameters which govern transition temperatures and magnetic field properties, with an ultimate goal of being able to specify the characteristics of and to produce materials of greater utility in space; also studies are made to enhance the capabilities of superconducting quantum instrumentation such as thin film microbridge magnetometers for space experiments and technological applications. It has been recognized for some time that valuable improvements in semiconductor electronics for space as well as commercial applications are possible by improving the surface characteristics of the materials used in their construction. Because of the urgent needs for efficient solar energy conversion devices for terrestrial applications in connection with the energy crisis, the investigations of basic processes of semi-conductors, especially surface effects, look uniquely promising in payoff. In-situ studies of surfaces characterized on atomic scale are proposed in order to obtain systematically a better insight of various atomic and electronic processes which affect the energy conversion process at the surface of a semiconductor, as for instance, charge carrier recombination, mobility, etc.

W74-70248 **502-01-04**
Lewis Research Center, Cleveland, Ohio.
INTERDISCIPLINARY LABORATORIES FOR MATERIALS

RESEARCH
R. A. Lad 216-433-6601

The objectives are to: (1) obtain new understanding of the relationships between electronic, atomic, molecular and microscopic structures of solids and their useful mechanical, structural, electronic and chemical properties; (2) employ the expertise existent in universities to obtain knowledge in these areas and to aid in determining the best directions to follow in improving existing materials and obtaining new materials of direct interest to NASA programs. Research is conducted at Rensselaer Polytechnic Institute (emphasis on physical metallurgy), Rice University (solid state physics and metal physics) and the University of Washington (ceramics). These programs are interdisciplinary in character and involve participation in several departments at each school. Research topics include interatomic forces in solids, corrosion, diffusion, polymer rheology, composites, computer memory materials, hydrogen embrittlement, superconductivity, grain boundary mobility in ceramics, solid electrolytes, dispersion strengthening, electromigration spacecraft coating materials, crystal growth, computer memory materials and others. The research is chosen to be of direct interest and utility. The results are disseminated in summary reports, journal publications and typical conferences.

W74-70249 **502-01-05**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
NON-METALLIC SUPERCONDUCTORS
John W. Lucas 213-354-4530

The primary objective is to ascertain the feasibility of synthesizing a high temperature superconductor. The achievement of the objective requires understanding and investigations of new theories and new systems leading to superconductors of relatively high transition temperatures. The general approach involves an experimental study of a two-dimensional model. This is achieved either by incorporation of molecular layers of metals into layered structures of semiconductors (e.g., molybdenum disulfide) or incorporation of polarizable systems into metallic layered compounds (e.g., niobium diselenide, tantalum disulfide). The polarizable systems which will be investigated will consist of organic molecules, semiconductors, and polarizable polymers, e.g., polysulfur nitride. Spectrophotometric studies will be carried out on the latter system to ascertain the feasibility of an excitonic mechanism. The two-dimensional model based on thin metal film deposition on semiconductors will be investigated by Dr. A. Hermann at Tulane. He will also determine the transport properties of organic model superconductors. In addition to the two-dimensional model, work will be continued on the one-dimensional model under subcontract to Prof. W. Little at Stanford University. He will evaluate the platinum cyanine dye complexes as possible excitonic superconductors and develop computer molecular modelling.

W74-70250 **502-01-06**
Lewis Research Center, Cleveland, Ohio.
RELATIONSHIP OF ATOMIC STRUCTURES WITH MATERIAL PROPERTIES
W. D. Klopp 216-433-6676
(501-01-06)

The objective of this program is to elucidate the relations between atomic and microstructural properties for refractory iron- and nickel-base alloys in order to guide the development of these materials for advanced space applications. The approach consists of: (1) determination of the controlling mechanisms for the formation of dispersoid-free zones as a result of diffusional creep in dispersion-strengthened alloys; (2) investigation of the correlation between magnetic susceptibility and low temperature solution softening in dilute body-centered-cubic alloys; and (3) determination of the relationship and mechanism of grain size effects in creep of nickel and binary nickel alloys, including solid solution strengthened, precipitate strengthened, and dispersion strengthened alloys.

W74-70251 **502-01-07**
Lewis Research Center, Cleveland, Ohio.
FUNDAMENTAL MATERIALS FOR LUBRICATION
R. L. Johnson 216-433-4000
(502-31-51; 501-24-10; 502-21-24)

Basic materials and lubricants studies as well as experiments and analyses will be conducted. Materials studies include atomic, molecular and crystalline and surface physics and chemistry considerations in controlled environments. The potentials of self-lubricating materials are being explored. Research tools such as LEED (low energy electron diffraction), auger emission spectroscopy analysis, field ion/ field emission microscopy and scanning electron microscope will be used to study fundamental adhesion, friction and wear behavior. Surfaces will be examined with these tools during dynamic experiments.

W74-70252 **502-01-08**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
VISCOELASTIC PROPERTIES OF POLYMERS
John W. Lucas 213-354-4530
(502-24-46; 502-04-45)

This is a program of fundamental research on the mechanical behavior of polymers. It is intended to determine the molecular parameters which control rheological behavior. This has been successful in simple amorphous systems which are not chemically reacting. The goal now is to extend this work first to longer times, where degradation may set in, and then to shorter times, where the material is glass-hard. The general approach should involve the syntheses of both new and modified polymeric and prototype chemical structures, the characterization of these materials and the determination of chemical structure and property relationships. Applications for the mechanical properties work might range from improved solid propellants, expulsion bladder and valve seat materials for liquid propulsion, sealants for high-speed aircraft, new types of reinforced plastics, and high reliability belts and tapes for spacecraft magnetic recorders.

W74-70253 **502-21-20**
Lewis Research Center, Cleveland, Ohio.
ADVANCED MATERIALS FOR SPACE
W. D. Klopp 216-433-6676
(501-21-20)

The primary objective of this program is to characterize the suitability of present materials and to develop new materials for advanced space systems, such as reentry vehicle structures and heat shields. The approach consists of: (1) development of new iron-base alloys with high fracture toughness over a wide range of temperatures (-435 F to 1000 F); (2) determine feasibility of developing chemical vapor deposition techniques for depositing high strength alloys and wire reinforced composites; (3) to conclude the process and material development of coated columbium and coated tantalum systems for metallic reentry vehicle heat shields; and (4) to explore the feasibility of developing improved ceramic fiber systems with suitable high temperature stability for advanced reusable surface insulation heat shield concepts.

W74-70254 **502-21-20**
Langley Research Center, Langley Station, Va.
ADVANCED MATERIALS FOR SPACE
George W. Brooks 703-827-2042

The objectives of this research are: (1) to develop improved materials and materials combinations for advanced space applications: (2) to apply the numerical methods which have been developed in other disciplines, and thereby to achieve better understanding and more effective application of materials; and (3) to develop in-house capability for determining thermal, physical, and mechanical properties of materials. Concepts for improved structural or protective materials will be developed and evaluated. Basic processes, such as diffusions and chemical reactions which occur during materials processing or in service, will be studied, and based on a better understanding of these mechanisms, modifications in composition or processing will be made to improve performance. New or more accurate methods will be developed to measure key materials characteristics as required.

W74-70255 **502-21-24**
Lewis Research Center, Cleveland, Ohio.
MATERIALS FOR BEARINGS, SEALS AND LUBRICANTS
R. L. Johnson 216-433-4000

(502-31-51; 501-24-10; 502-01-07)

Materials, including lubricants studies will be conducted as well as experiments with actual mechanical components (e.g., seals and bearings) for vacuum, cryogenic, inert gas, and low viscosity fluid environments. Materials studies will be conducted in very carefully controlled environments. Rheology studies of lubricants will seek to explain behavior in thin films of concentrated contacts on molecular and continuous bases at high stresses under both steady state and transient conditions. Ion plating and sputtering processes will be utilized in achieving solid lubricating coatings; the characteristics and performance in films will be determined. The application of lubricating material technology to bioengineering of ambulatory prostheses will be pursued.

W74-70256 **502-21-27**
Goddard Space Flight Center, Greenbelt, Md.
SPACE VEHICLE THERMAL CONTROL - HEAT PIPES, VACUUM DEPOSITED COATINGS
Stanford Ollendorf 301-982-5228

The objectives of this task are to improve both the capability and reliability of spacecraft temperature control in the following manner: develop more reliable heat pipes and vapor chambers in the ambient and cryogenic temperature range; and develop stable thermal control coatings. For the heat pipe technology, the approaches considered are: (1) Develop reliable high performance heat pipes for ambient temperatures; use this technology to develop isothermal vapor chambers and investigate extending the temperature range to the cryogenic ragion. (2) Establish heat pipe performance in the zero-g environment via sounding rocket experiments. For the coatings development, the approach is to develop low alpha/epsilon coatings which have stable low outgassing, and have well defined reproducible optical properties.

W74-70257 **502-21-27**
Ames Research Center, Moffett Field, Calif.
THERMAL CONTROL
John V. Foster 415-965-5083

The objectives are: (1) to develop basic control mechanisms by which heat pipes may achieve variable conductance, feedback control, or thermal diode performance; (2) to improve liquid transport capacity and reliability; and (3) to participate in flight tests of advanced heat pipe technology to establish flight level confidence. The Ames Research Center shall act as the lead OAST Center and provide guidance to OA, OSS, and OMSF in this capacity as a means of extrapolating basic understanding into practical missions. Development of basic control techniques will be continued with increased emphasis on cryogenic thermal diodes and vapor controlled variable conductance heat pipes. Investigation of active and passive feedback control will also be continued, but the development of gas-controlled variable conductance heat pipes will be concluded. Liquid transport capacity and reliability will be increased through a deeper understanding of gas occlusions in arteries, development of gas invulnerable and flexible arteries, and continued research into electrohydrodynamic pumping. Emphasis will be increased in the cryogenic region where liquid transport capacity is currently limited. The Ames Heat Pipe Experiment (AHPE) on OAO-C and the Advanced Thermal Control Experiment (ATFE) on ATS-F will be supported.

W74-70258 **502-21-33**
Lewis Research Center, Cleveland, Ohio.
MATERIALS FOR HIGH-POWER LASERS
R. L. Davies 216-433-6608

This program involves the development of materials technology and materials for use in high-power lasers. The program includes: the development of an understanding of damage mechanisms in laser optical components (windows and mirrors); the determination of effects of time in the laser environment on materials properties; the identification of improvements needed in suitable candidates for laser optics; and the identification of studies needed on container materials for advanced laser concepts. The major objectives of the program are to: (1) determine the effect of long-time exposure on laser optical components (windows and mirrors) which are exposed to laser environments; (2) conduct fundamental studies into the basic degradation processes of laser optical materials; (3) identify suitable candidate materials for short wavelength laser optics (wavelenths > 0.5 micrometer to < 6 micrometer); and (4) maintain cognizance of advanced laser system designs for the purpose of identifying materials problems associated with laser cavity or constructional materials.

W74-70259 **502-21-27**
Marshall Space Flight Center, Huntsville, Ala.
THERMAL CONTROL
D. W. Gates 205-453-3102

As a continuation of work in the thermal-control coatings field, our efforts will be directed toward methods of improving NASA's capabilities of controlling spacecraft temperatures. Effort will be directed toward improvement of the white paints and their reliability for extended mission requirements. While maintaining the 0.9 epsilon required in the present thermal designs for space station, the delta alpha must be a minimum to obtain the required total life or the least EVA required to restore the thermal-control surfaces. This is being done by improving both binders and pigments, and protection of the coating after application, to its eventual mission requirement. Backup knowledge for these development efforts will include laboratory studies of coatings, measurement design parameter data and long lifetimes of coatings and their substrates at cryogenic temperatures. Maximum effort will be toward reducing the present best white paint, composed of ZneTi04 pigment in an 0l-650 glass-resin binder, to a NASA Specification coating.

W74-70260 **502-21-27**
Langley Research Center, Langley Station, Va.
THERMAL CONTROL
George W. Brooks 703-827-2042

An experimental program is in progress to define, study, and solve the problems associated with utilization of second-surface mirror coatings for passive thermal control of spacecraft. The development of the technology necessary to economically utilize second-surface mirror coatings on large spacecraft surfaces will be emphasized. Experimental aromatic-heterocyclic polymers will be evaluated to provide improved radiation stability for the second-surface mirror coatings. The approach shall include: (1) understanding the principles of second-surface mirrors, determining the materials to be employed, and developing complete coating systems and procedures for their application to spacecraft; and (2) the continued use of the space environmental effects system facility to evaluate the radiation stability of thermal control coatings.

W74-70261 **502-21-27**
Lewis Research Center, Cleveland, Ohio.
THERMAL CONTROL
R. Breitwieser 216-433-4000

The objective is to establish heat pipe materials technology for long lifetimes and more efficient operation, and to understand corrosion mechanisms in all temperature ranges from high to cryogenic. The general approach shall include: (1) establishing corrosion/gas generation mechanisms in heat pipes in all temperature ranges from very high to cryogenic; (2) establishing materials selection, processing and joining requirements for heat pipes in all temperature ranges; and (3) studying those special problems inherent in the operation of heat pipes at temperatures of 700 F and above. Specific problems to be investigated include: (1) gas generation in stainless steel and aluminum pipes; (2) sludge deposits in aluminum - ammonia heat pipes; and (3) corrosion in liquid metal refractory alloy heat pipes.

W74-70262 **502-21-28**
Marshall Space Flight Center, Huntsville, Ala.
OPTICAL CONTAMINATION OF SPACECRAFT
Hoyt M. Weathers 205-453-3040
(645-20-08)

The induced environment around spacecraft, both manned and unmanned, does exist and has seriously degraded the results of several measurements and experiments. The contamination can originate from many sources, including material outgassing,

particulates and debris, vents of several kinds, attitude thruster firings, leakage, and even from within experiments. A program for the study, control, monitoring, and abatement of contamination has been established within the Space Sciences Laboratory as the key activity in the overall MSFC program in this area. This program is vital to the determination of the degradation of the optical properties of astronomical instruments, thermal control, and other critical optical surfaces to be used on Skylab space shuttle, sortie lab, and LST. In order to continue the optical contamination effects work at MSFC and to provide the research which is basic to a better understanding of these effects, it is essential that the tasks defined in this RTOP be continued.

W74-70263 **502-21-29**
Langley Research Center, Langley Station, Va.
SPACE DEBRIS STUDIES
Eugene S. Love 703-827-2893

The broad objective is to provide on a continuous basis to the designers of future spacecraft sufficient knowledge of the meteoroid environment and the effects of the meteoroid environment on space operations to insure proper mission planning and implementation. Models of the meteoroid environment in the solar system will be generated and periodically updated as new data are obtained. Particular attention will be given to the meteoroid environment in the asteroid belt and in space near major planets such as Mars, Jupiter, and Saturn which are currently planned as targets for flight investigations. The effects of meteoroid impacts on spacecraft will be studied both analytically and experimentally. The Langley Research Center will serve as the lead Center for all OAST meteoroid research. The talents and resources of other Centers will also be utilized. All available meteoroid data from flight experiments, meteor observations, zodiacal light measurements, asteroid observations, etc., will be used to generate the environmental models. Laboratory particle accelerators will be used to investigate impact damage. Meteoroid damage predictions will be made for most major NASA spacecraft and the flight performance of these spacecraft will be observed to generate feedback into the environment models for updating or simply improving confidence levels. Man-made debris, particular in earth orbit, will also be considered and fed into spacecraft damage prediction models.

W74-70264 **502-21-30**
Goddard Space Flight Center, Greenbelt, Md.
ENVIRONMENTAL DESIGN CRITERIA
Scott A. Mills 301-982-4246

This research is being conducted to develop, publish, and keep current NASA design criteria monographs that present state-of-the-art models of terrestrial and extraterrestrial environments. The objectives are to increase space vehicle reliability, and to achieve design and management economies. The published environmental models are providing an established reference for the designers, mission planners, and experimenters in NASA, industry, and universities who are participants in flight programs. As lead center, GSFC initiates, coordinates, and reviews the support of the Centers associated in the program (MSFC and JPL) and the efforts of participating scientists, engineers, and contractors. A related task that also aims to improve space vehicle reliability is formulation of GSFC general specifications for testing spacecraft and components. Revisions are made in response to findings from test and flight experience or when NASA adopts new or modified launch vehicles. Revisions also are expected because of the changing test philosophy and requirements that are associated with efforts for greater cost effectiveness.

W74-70265 **502-21-32**
Langley Research Center, Langley Station, Va.
RADIATION SHIELDING AND DOSIMETRY
Eugene S. Love 703-827-2893

The objectives are to: (1) experimentally obtain data on the production of nucleons and heavy ions from elemental materials under high-energy proton and alpha particle bombardment, and improve biological dose calculations for manned space missions and aeronautics; (2) develop a real-time REM dosimeter for extended manned space missions such as Skylab and space shuttle; (3) make a critical analysis of current active dosimetry methods of monitoring dose to internal organs; (4) develop models for the interaction of heavy ions with heavy nuclei for heavy ion shielding studies; (5) continue to maintain technical capabilities for support of Langley programs, such as Viking, SST, HST, and Langley flight experiments which may be adversely affected by radiation; and (6) continue effort to determine the damaging effects of space radiation on various types of photographic film proposed for space experiments and report on results.

W74-70266 **502-31-50**
Langley Research Center, Langley Station, Va.
SHUTTLE EXTERNAL INSULATION
George W. Brooks 703-827-2042
(502-37-02)

The objectives of the program are: (1) to develop improved reusable surface insulation (RSI); (2) to develop specialized techniques and instrumentation and apply these to obtain a complete characterization of shuttle RSI in all operational environments; and (3) to determine characteristics of other materials, such as strain isolator bonds and strain arrestor plates, which are required for use of RSI on the shuttle. Improved RSI materials will be developed for the upper surface of the space shuttle which experiences lower maximum temperatures. Improvements in both cost and performance will be examined. Samples of the RSI which are to be used on the shuttle will be tested over the range of environments encountered in the shuttle mission cycle. The effects of these environments on the materials will be determined through mechanical property tests, high temperature emittance measurements, X-ray diffraction studies, and electron microscope examination. Thermal and mechanical properties of the materials used to attach RSI to the shuttle structure will be determined.

W74-70267 **502-31-50**
Lewis Research Center, Cleveland, Ohio.
SHUTTLE EXTERNAL INSULATION
S. J. Grisaffe 216-433-4000

This research and development effort is related to reusable surface insulation (RSI), the prime TPS candidate for the Space Shuttle Orbiter, as well as to advanced thermal protection systems. The objectives of this work may be briefly summarized as follows: (1) to improve the surface character of RSI bodies, and (2) to seek improved fiber compositions and examine their potential for RSI and other forms of fibrous insulation. Improved surface characteristics will be sought through coating development. Coating materials will be compatible with, but completely independent of, the RSI fabrication processing steps. Primarily contractual efforts are anticipated. Optimized and improved fibers will also be sought and evaluated primarily by contractual efforts.

W74-70268 **502-31-50**
Ames Research Center, Moffett Field, Calif.
SHUTTLE EXTERNAL INSULATION
Glen Goodwin 415-965-5065

The objective is to improve the physical characteristics and thermophysical performance of reusable surface insulation (RSI) materials through a materials research program. This program will address itself to the determination of the effects of processing parameters, variations in raw materials, impurity levels, and coating composition on both the physical properties and thermophysical response of this class of materials to aerodynamic convective heating environments. Improvement of coating technology will be a primary objective, and other systems that are of interest will be studied. The effects of cyclic aerothermal exposure on the state-of-the-art RSI materials supplied by the vendors and Ames fabricated RSI materials will be determined using scanning electron microscopy, X-ray diffraction, chemical analysis, differential thermal analysis, etc. Changes in crystallinity, morphology and chemical composition will be determined. Materials will then be fabricated in-house and on contract to obtain improved properties based on the results of the pretest and post-test analysis of the materials exposed to the aerothermal environment. Raw materials, chemical composition, fiber binder ratio, fiber size, compaction technique curing cycle, coating morphology, optical properties, composition and coating techniques will be studied

where applicable. Improved materials will again be exposed to the aerodynamic convective heating environment.

W74-70269 **502-31-51**
Lewis Research Center, Cleveland, Ohio.
BEARINGS, LUBRICANTS AND SEALS FOR SHUTTLE
R. L. Johnson 216-433-4000
(502-01-07; 501-24-10)

Materials and lubricants selection, development, design, theory, analysis and experimentation of bearings and seals will be performed under extreme conditions associated with (1) engine and (2) vehicle components subject to lubrication, friction, wear and hydraulics problems. Components must function in cryogenics, after exposure to vacuum, and in air at extreme temperatures. Rolling element bearings and face type seals for hydrogen pumps of shuttle engines will be operated under conditions simulating problem areas. Vehicle frame control bearings, hydraulic fluids, and seals for actuation systems of flight control surfaces will be studied. Minimum weight, efficiency and extended life are essential.

W74-70270 **502-02-01**
Lewis Research Center, Cleveland, Ohio.
LARGE LASER MIRROR FOR SPACE
D. L. Nored 216-433-6948

This program will investigate preliminary conceptual feasibility of large structures to support and point large (approximately 20 meter diameter) mirror systems in space for the purpose of transmitting or receiving high-power laser beams. Workable concepts for the packaging and deployment of such structures will be investigated (such structures to maintain the spacing of various elements of a transmission system to within a fraction of a wavelength). A detailed analysis will be performed to catalog significant parameters, define operational criteria, and select or conceive new structural concepts. A conceptual design will be performed to the extent necessary to instill an acceptable level of confidence of feasibility.

W74-70271 **502-22-02**
Lewis Research Center, Cleveland, Ohio.
COMPOSITE TANK TECHNOLOGY
R. H. Kemp 216-433-4000

Composite pressure vessels and propellant tanks offer a variety of attractive advantages in space vehicle applications. Due to the high structural efficiency of the constituent materials, the composite pressure vessel is lighter in weight than an all-metal vessel. This is very important where even a small weight savings can be significant for upper stage space vehicles such as shuttle orbiter ($30K/lb) and tug ($160K/lb). The catastrophic shrapnel-type failure of a metal pressure vessel can be prevented through application of composite technology. This provides a reliability advantage which is not directly relatable to a cost savings but is currently a major driver in system configuration selections. In addition, a wide variety of composite pressure vessel configurations can be designed to provide optimum combinations of thermal, structural, and weight characteristics. The principal objective of this effort is therefore to establish the characteristics of, and obtain design information on, composite pressure vessels fabricated from a variety of composite materials including S-glass, PRD-49, and graphite fibers in epoxy and polyimide matrices. In this context, a pressure vessel is considered to be a complete structural system and due to the porous nature of composites, a liner is required. Both structural (load bearing) and nonstructural (thin-metal) liners are therefore a part of this effort and materials such as aluminum, Inconel, cryoformed steels, and titanium are considered for liner application.

W74-70272 **502-22-03**
Lewis Research Center, Cleveland, Ohio.
FRACTURE CONTROL TECHNOLOGY
R. H. Johns 216-433-6380

Work to be conducted under this RTOP is intended to provide design criteria and structural integrity data for application to the design, fabrication, and operational decisions which are inherent in the development and utilization of advanced launch vehicle and spacecraft systems. Both primary structure and propulsion system components are included. The fracture control programs initiated in previous fiscal years in direct support of the shuttle vehicle will be concluded. New programs intended to develop structural integrity assurance for spacecraft structures with emphasis on innovative applications of advanced composite materials will be initiated. Specific FY 1974 programs will include development of structural design criteria for reliable, reusable, upper stage H-O rocket engines. The factors for establishing optimum design conditions for structurally-efficient lightweight propellant tanks will be developed by a second FY 1974 program.

W74-70273 **502-22-05**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
ADVANCED CONCEPTS FOR SPACECRAFT ANTENNA STRUCTURES
John W. Lucas 213-354-4530
(502-23-12)

Outer planet and planetary orbit missions in the 1975-1985 period will require substantially increased communication capabilities. JPL studies indicate that optimum telecommunication design for these missions is realized with antennas having much higher gain than those now used on Mariner spacecraft; however, the assumed gain vs. weight used in these studies has not been verified, nor is the technology sufficiently well developed. The principal objective of this effort is to fulfill the need to develop and make available the knowledge required by flight project to be able to utilize new large antennas. A number of furlable antenna configurations have been considered from 15 to 100 feet in diameter for operating radio frequencies up to X-band. The technical approach is to demonstrate feasibility on small scale development models and to design and fabricate larger models such as 14-foot and 5-m diameter furlable conical antennas. Nonfurlable conical antennas will also be considered due to the recent success of line source feed development. The technology will then be investigated for extrapolation to antennas of larger size. Criteria: weight (goal is 0.25 lb/sq ft), surface accuracy in the operating environment, reliability of deployment, long life, and amenability to preflight verification by analysis and tests. This effort will be coordinated with Microwave Deep Space Communications and Tracking, RTOP Code 502-23-12. Another objective of this RTOP is to improve and maintain structural analysis techniques permitting better definition of loads, response analysis, and test simulation of the entire spacecraft carrying large antennas.

W74-70274 **502-22-06**
Goddard Space Flight Center, Greenbelt, Md.
STOP (STRUCTURAL-THERMAL-OPTICAL-PROGRAM)
H. P. Lee 301-982-5275

The objective of this RTOP is to advance analytical capabilities in combined disciplines by developing methods in respective areas and unified computer programs. The resulting capabilities are suitable for use in both design and evaluation. The degradation in performance of a space-borne telescope or RF antenna is chiefly due to thermal loads caused by the varying orbital conditions. The approach is to develop a general purpose heat transfer computer program compatible with the structural version of NASTRAN which, by its intrinsic characteristics, is suitable to computer automation and extremely versatile in regard to variations in configuration, properties, etc. The unified thermal-structural model simplifies the discipline interface and permits a virtually unlimited sized problem. The structural results are then used as input, through an interface computer program, to ray trace programs for optical or RF performance analysis. Analytical capabilities to assess sensitivity of temperature and displacement variances of thermal and structural analyses due to uncertainties inherent in input values of the system parameters are also pursued in this RTOP.

W74-70275 **502-22-07**
National Aeronautics and Space Administration, Washington, D.C.
SHOCK AND VIBRATION INFORMATION CENTER (SVIC)
Douglas Michel 202-755-3280

The SVIC is a government and industry sponsored facility located at the Naval Research Laboratory that provides a focal

point and source for shock and vibration information. It receives, its support principally from DOD and NASA.

W74-70276 **502-22-08**
Langley Research Center, Langley Station, Va.
GENERAL PURPOSE ANALYSIS AND DESIGN TECHNOLOGY FOR AEROSPACE STRUCTURES
George W. Brooks 703-827-2042

The objectives are to develop technology to improve the effectiveness of computers in the analysis and design of aerospace structures. The two major thrusts involved are to develop a system of integrated programs for aerospace-vehicle design (IPAD) for use by the aerospace industry as a tool for design of large, complex vehicle systems, and to manage and improve the NASTRAN computer program which provides a universal analysis capability for all types of large, complex structures. IPAD is intended to facilitate increased automation in the design process and to engage the computer in the extensive data transfer and management task in vehicle design. It should be applicable at various levels of design and should harness existing disciplinary computer programs, as well as those developed in the future which represent the most advanced state-of-the-art in a highly computerized system. The goal is the most effective combination of man and the computer to accomplish the total design task. NASTRAN is intended to evolve into the premier structural analysis system in the nation with continued improvements in overall efficiency, user convenience and effectiveness, structural element representation, and technical capability. The IPAD system definitions generated by the feasibility studies which were initiated in April 1972 will be evaluated by potential user firms. The content of the industrial IPAD will be established and an RFP prepared for the development of the system. Contract and in-house research enhanced by the GWU Research Cell on Automated Design will focus on selected issues in IPAD technology. There is no effort for NASTRAN under this RTOP in FY-74; however, NASTRAN work for FY-75 and subsequent years will be included herein.

W74-70277 **502-22-09**
Lewis Research Center, Cleveland, Ohio.
COMPOSITE MATERIALS APPLICATION TO STRUCTURES
J. C. Freche 216-433-4000

Composite materials offer a high potential for reducing the weight of many structural components. However, before full advantage can be taken of the unusual properties of composite materials in such applications, considerable material property and design information is needed. It is proposed that studies be continued that will: (1) develop (in-house) analytical design techniques for predicting structural characteristics of given composite configurations; (2) develop (in-house) analytical design techniques for otpimizing composite structures for minimum weight; (3) improve (in-house) a multiaxial testing facility for measuring the mechanical properties of fiber composites under complex loadings and environments; (4) determine (by contract) the effects of fatigue on the load-carrying ability of composite structures; (5) develop (by contract) improved finite element capability consistent with NASTRAN requirements to permit improved stress analyses of fiber composite components; and (6) determine (by contract) the effect of impact by foreign objects on the structural integrity of advanced fiber composites. The studies outlined above have been reviewed and coordinated with cognizant Langley Research Center personnel and do not duplicate work at that Center.

W74-70278 **502-22-10**
Langley Research Center, Langley Station, Va.
ADVANCED SPACE STRUCTURES
George W. Brooks 703-827-2042

The objectives are: (1) to extend the technology of advanced space structures to the point where fully evaluated viable concepts of structural configurations for future space missions exist; and (2) to provide the methodology and data base that will permit the spacecraft user to select with confidence the most effective configuration from a weight, performance, cost, and reliability standpoint. Two classes of advanced spacecraft will be investigated: those that need large area deployable structures to perform their mission, and those that require ultra lightweight, lightly loaded structures such as the space tug. The objectives will be achieved through three complementary combined in-house and contractual studies to: (1) define operational and structural requirements for future space missions; (2) define, develop, and evaluate advanced structural concepts for lightly loaded structures with a class of geometrical shapes expected on future space missions; and (3) develop appropriate merit functions that will permit meaningful comparison of the various concepts. These merit functions will be used to define the most promising advanced concept for several future space missions. The selected concept will then be designed, fabricated, and ground tested to validate the methodology used in its selection and design.

W74-70279 **502-22-11**
Goddard Space Flight Center, Greenbelt, Md.
SPACE VEHICLE DYNAMICS
Young J. P. 301-982-4964

Overall objective is to reduce cost and increase effectiveness of structural evaluation and reliability demonstration services for spacecflight hardware. This objective will be approached through a study of means to improve the cost effectiveness of both test and analysis services. Most specifically, contributions to the above objective during FY 1974 will be met by concentrated activity in two areas. These will be a continued study of optimized test level and a study of cost effectiveness of subsystem testing.

W74-70280 **502-22-11**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
SPACE VEHICLE DYNAMICS
John W. Lucas 213-354-4530

The principal objective of this four-year effort is to perform research and advanced development in structures and dynamics design, analysis, and testing in order to reduce the cost of future spacecrafts and shuttle payloads. Shuttle payload related activities are to be coordinated with OMSF. The total effort in establishment of design criteria, loads, design, development tests, and qualification tests is to be reviewed with constraints such as weight, schedule, risk, and cost. The criteria used on past NASA projects will be reviewed prior to selection of constraints and methods potentially of most benefit to NASA in the shuttle era. In FY-74, a 5-year research and advanced development plan in dynamics will be prepared that meets the objectives. Future areas of investigation will be based upon the 5-year plan. Wherever feasible, the results will be continually compared to the Viking Orbiter's existing load analysis, test data, flight data, cost, and schedule data to provide extensive information that will be used as a basis for this activity.

W74-70281 **502-22-11**
Langley Research Center, Langley Station, Va.
SPACE VEHICLE DYNAMICS
George W. Brooks 703-827-2042
(502-32-02)

The objective of this research is to reduce the cost of spacecraft and payloads by reducing the design and test costs associated with the dynamic environment of launch and space operation. The approach is to conduct analytical and experimental research programs to better define the vibration environment of space vehicles, to develop improved and more routine methods of testing, and to develop better vibration isolation systems. Such improvements in environment definition, testing, and isolation will lead to less stringent design specification, improved payload reliability, fewer and more realistic qualification and flight acceptance tests.

W74-70282 **502-22-11**
Marshall Space Flight Center, Huntsville, Ala.
SPACE VEHICLE DYNAMICS
R. W. Schock 205-453-4387

The general objective of this RTOP is to derive and develop space vehicle structural dynamics technology to effect reduction of spacecraft and payload program costs. Implied in this objective is the requirement to have the payload mission design the payload instead of the launch environment and verify and qualify the

payload with a minimum test program. Methods for accomplishing space vehicle dynamics cost reductions are discussed in the following approach. Candidate solutions for reducing program costs associated with space vehicle dynamics will be evaluated under this RTOP. These candidate solutions are the development of new and/or improved qualification test philosophies and techniques which will provide more exact simulations of operational environments, reduce test costs, and provide quantifiable factors of safety such that redesign and retest costs can be minimized. More accurate methods of predicting dynamic loads and the response of the structure, subsystem, or payloads to the loads will be developed to define more accurate test programs and/or reduce the requirements for the test programs. Methods for controlling the launch vehicle induced environment level and active isolation techniques will be developed. These are commonly called modal suppression and load relief; however, the state-of-the-art needs to be extended in all likelihood to the adaptive approach. In addition, high fidelity dynamic models will be required, using subcomponent synthesis. To accomplish this, control schemes (modal suppression load relief) that would introduce a minimum dynamic load into the payload bay and active isolation approaches for the payloads themselves will be developed.

W74-70283 **502-22-11**
Ames Research Center, Moffett Field, Calif.
SPACE VEHICLE DYNAMICS
H. M. Drake 415-965-5851

The objective of this research is to provide improved prediction methods and data on the dynamic loads resulting from aerodynamic noise, the response of structures due to noise, noise transmission, interior noise, and exhaust plume interactions with the flow field and the resulting effects on dynamic loads. The research on dynamic loads will include basic experimental studies of surface pressure fluctuations due to attached and separated boundary layers and shock waves at transonic, supersonic and hypersonic speeds. Empirical formulas that predict the temporal and spatial characteristics of the nonsteady loads will be derived from these data. Research on panel response and noise transmission, analytical with experimental verification, will be directed to the development of computational methods for predicting panel response to noise, pressure wave propagation through materials, and radiated noise to the interior of a vehicle.

W74-70284 **502-22-12**
Lewis Research Center, Cleveland, Ohio.
NONDESTRUCTIVE EVALUATION OF SPACE STRUCTURES
R. L. Davies 216-433-6608

This program involves the development of advanced technology required for improved nondestructive evaluation (NDE) of future space vehicle structures. The work will primarily be directed toward meeting the expected quality assurance needs of the space tug and advanced versions of the space shuttle. Emphasis will be on determining the structural quality and assessing multiflight reusability of critical propulsion components (e.g., propellant tanks, combustion chambers, thrustor nozzles, etc.). The main thrust of this work will involve transferring advanced NDE techniques from laboratory use to field inspection and in-flight monitoring. This will include: (1) the evaluation of advanced NDE techniques on complex hardware configurations (sub-scale); and (2) development of automated signal processing and analysis methods to reduce the time and costs associated with inspection, and to put structural assessment on a more quantitative basis.

W74-70285 **502-32-01**
Langley Research Center, Langley Station, Va.
SHUTTLE STRUCTURAL DESIGN TECHNOLOGY
George W. Brooks 703-827-2042

The objectives are to evaluate the integrity and aerothermal performance of shuttle TPS concepts by tests in the 8-ft High Temperature Structures Tunnel and the Thermal Protection System Test Facility (TPSTF), and through contractual effort maintain and improve the NASTRAN system to the level required for the primary structural analysis tool for space shuttle.

W74-70286 **502-32-02**
Langley Research Center, Langley Station, Va.
SHUTTLE DYNAMICS AND AEROELASTICITY
George W. Brooks 703-827-2042

The objective of this research is to develop the structural dynamics, aeroelasticity, loads, and structural acoustics technology for the support of space shuttle vehicle programs. The technology under development is directly applicable to specific problems such as vehicle dynamic behavior and control; liquid-structure interaction and liquid suppression; pogo; flutter, buffet and ground winds; aerodynamic loads; engine and aero-noise environments and the integrity of systems within the shuttle noise and thermal environment. Both analytical and experimental approaches are required to determine critical loading conditions, vehicle dynamic responses, stability boundaries, control requirements and fatigue factors. Dynamic models and wind tunnels are being used extensively for this in-house and contract effort. The results will support the shuttle development and lead to lighter weight, more reliable flight systems with a minimum of full-scale testing.

W74-70287 **502-32-02**
Ames Research Center, Moffett Field, Calif.
SPACE SHUTTLE DYNAMICS AND AEROELASTICITY
H. M. Drake 415-965-5851
(501-22-05; 502-37-01)

Wind tunnel test support and analysis will be provided to investigate transonic buffet (including aeroelastic effects), aerodynamic noise inputs and response, and flutter of a space shuttle vehicle. Rocket exhaust plume will be simulated by cold jets so that static and dynamic loads can be measured in a realistic launch environment. Models will be tested as needed to investigate buffeting and flutter, and pressure fluctuations will be measured in regions of high intensity turbulence to evaluate aerodynamic noise inputs.

W74-70288 **502-04-01**
Lewis Research Center, Cleveland, Ohio.
ION THRUSTER RESEARCH
R. C. Finke 216-433-4000
(502-24-03)

The broad objective of the work described herein is to provide the basic research needed to increase in an orderly and meaningful manner the knowledge of the behavior of electrostatic thrusters and their interaction with the spacecraft to be employed in communication and scientific missions. By conducting pertinent experimental and analytic studies, the overall program is directed at obtaining a more thorough understanding of the basic physical processes: (1) occurring in and external to electrostatic thrusts; (2) interacting with the spacecraft or its intended mission; and (3) resulting from thruster/power conditioner/control system interactions. Major programs are directed at searching for basic understanding of thruster and spacecraft interactions to permit refinement of the designs of a given thruster and spacecraft to enable the combined system to experience no significant degradation in mission performance. Specifically, the basic research goals are to investigate the surface deposition of materials from thruster component erosion, the electromagnetic and magnetostatic interactions affecting the thruster/spacecraft interface, problems of ground simulation of thruster-spacecraft interactions in space, thruster space environment phenomena, theoretical and experimental thruster diagnostics and operation of various sized thrusters using xenon as a propellant.

W74-70289 **502-04-02**
Lewis Research Center, Cleveland, Ohio.
ADVANCED PLASMADYNAMIC LASER RESEARCH
G. R. Seikel 216-433-4000

The objectives are to investigate plasma laser concepts that show promise for applications of interest to NASA. Investigations are aimed at both understanding the physics of the processes and demonstrating the feasibility of high performance systems. Investigations will also attempt to define possible new applications which could be of interest. Analytical and experimental studies which include extensive diagnostics will be made. Novel concepts will be explored and attempts to demonstrate their feasibility in MW quasi-steady experiments will be made. Research

will include estimating performance of laser concepts, methods to convert laser energy to alternative forms, and direct use of lasers.

W74-70290 **502-04-20**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
SPACECRAFT LIQUID PROPULSION RESEARCH
Paul J. Meeks 213-354-2546
(502-24-26)

The chemical-physical processes that are the essence of liquid propellant rocket engines are being characterized. These processes include ignition, combustion and decomposition, the fluid dynamics and chemistry of nozzle flows, compatibility of chamber walls with reaction products and plume effects on spacecraft component/structure. The mixing effectiveness of various liquid/liquid, gas/liquid, and gas/gas propellant injection systems are being evaluated experimentally and the mechanisms that control mixing are being correlated with injector dimensions and operating conditions. An on-line high-speed mass-spectrometer, in combination with a molecular beam probe, is being used to relate engine conditions (compositions) and injector variables, and to bound the relevance of non-reactive data and predictions of analytical/computer models. The origin of solids deposited on low temperature surfaces is sought. The margin of stability for engines utilizing advanced propellants is being determined and modified as required to give a high confidence level for a successful mission. A combustion model (Distributed Energy Release) in conjunction with 2-dimensional nonlinear combustion instability models (COMB and TRDL) is being used to predict performance and stability margins. Densities and pressures within the exhaust plume of a small rocket nozzle are being determined using a cryogenic quartz crystal microbalance technique. Emphasis is on the back-flow region where instruments and spacecraft surfaces are located.

W74-70291 **502-04-21**
Marshall Space Flight Center, Huntsville, Ala.
LAUNCH VEHICLE PROPULSION TECHNOLOGY
K. W. Gross 205-453-3815
(502-24-21; 113-31-14; 113-31-12)

The objective of the effort described here is to develop a reliable and accurate boundary layer JANNAF reference program to predict performance loss and heat transfer in rocket thrust chamber and to obtain an improved understanding of the dynamics of cavitating turbopump inducers. The boundary layer integral matrix procedure (BLIMP) used to predict boundary layer loss will be either verified or modified as required by comparing its predicted results with available test data. The understanding of cavitating turbopump inducer dynamics which is essential for accurate vehicle POGO analyses will be accomplished by developing an analytical model employing finite cavity cascade theory and comparing the predicted compliance with the experimental results.

W74-70292 **502-04-25**
Lewis Research Center, Cleveland, Ohio.
CHEMICAL PROPULSION RESEARCH
D. A. Petrash 216-433-6860

The objectives of this work are: to provide basic analytical and experimental data to improve the performance, reliability and cost effectiveness of chemical propulsion systems and establish new and novel concepts that will provide large increases in propulsive performance. These objectives will be attained through theoretical studies to delineate the important design parameters required to achieve engineering improvements, experimental studies to demonstrate the validity of specific theoretical approaches and design parameters, and exploratory studies to investigate new techniques or theoretical approaches that will provide further engineering improvements in liquid rocket engines. Areas in which this effort will be applied are the following: (1) combustion; (2) fluid flow; (3) thermodynamic, transport and kinetic data; (4) contamination of spacecraft surfaces; (5) instrumentation; (6) application of lasers for propulsion and (7) mission and system analysis.

W74-70293 **502-04-35**
Lewis Research Center, Cleveland, Ohio.
RESEARCH IN ATOMIC AND METALLIC HYDROGEN AND ACTIVATED SPECIES
James C. Laurence 216-433-4000

Hydrogen is the lightest, simplest, and most prevalent of all the elements, and its low mass and availability are sufficient reason for its selection as a propellant and a fuel. Metallic hydrogen, if metastable, and atomic hydrogen, if storable, could provide energy-to-mass ratios exceeding those of any chemical reaction. The energy available from either metallic or atomic hydrogen is nearly the same and results from release of the 4 eV binding energy. Other metastable species such as He have up to 20 eV energy per mole. Metallic hydrogen is theorized to be a high temperature superconductor. The Lewis program will attempt to produce and stabilize atomic and metallic hydrogen and other activated species using approaches and equipment not available to previous investigators. Using the latest capabilities and techniques in dissociation of gases and the very high magnetic field strength and very low cryogenic temperature facilities available at Lewis, collection of significant quantities of atomic hydrogen and other activated species will be attempted. Shock wave and static high pressure techniques will be used in attempts to produce metallic hydrogen. Propellant specific impulse is a seriously limiting factor in chemical rocket---

W74-70294 **502-04-36**
Langley Research Center, Langley Station, Va.
PROPAGATION STUDIES USING EXTENDED WAVELENGTH TUNING OF CO AND HF LASERS
Eugene S. Love 703-827-2893
(502-10-01)

The objective of this research is to study propagation of CO and HF laser wavelengths through the atmosphere by performing laboratory studies of absorption of CO and HF laser wavelengths by atmospheric constituents (i.e., H2O, CO2). The CO laser radiates discrete wavelengths between 5 and 5.8 microns; the HF laser radiates discrete wavelengths between 2.65 and 3.00 microns. These lasers are important since they have demonstrated high efficiency and output power and are therefore suitable for a variety of NASA and DOD related applications. Furthermore, their wide wavelength coverage brings some of the emission wavelengths in spectral regions where the transmission through the atmosphere could be higher than that of the CO2 laser (10.6 microns). To perform this study, it is necessary to develop low power CO and HF lasers radiating over a wide wavelength range. In our laboratory, several subsonic low power CO and HF lasers have been constructed for propagation studies, but the wavelength coverage is limited (i.e., 5.2 to 5.8 microns for CO, 2.7 to 3.0 microns for HF). These wavelength ranges lie within totally absorbing regions of the atmosphere (e.g., subsonic CO emits within the 6.3 microns absorption band of H2O; subsonic HF emits within the 2.7 microns absorption band of H2O). Analytical studies recently performed at LaRC for HF and at AFCRL for CO show the presence of transmission windows (> or = 80%) at the edges of the known absorption bands of H2O at sea level under high resolution. These studies imply that by extending wavelength coverage of CO > 5.0 microns and that of HF > 2.8 microns, the transmissivity of the atmosphere would be greater than 80% for select lines of the---

W74-70295 **502-04-38**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
NEW HORIZONS IN PROPULSION
Paul J. Meeks 213-354-2546

The objective of this program is to identify new concepts in propulsion which offer significant improvements over systems which now exist or are in development when applied to a variety of future propulsion requirements. The approach is as follows: (1) identify new concepts; (2) define the concepts in sufficient detail to allow initial applications analyses; (3) evaluate applications for the new concepts; compare these concepts to current capabilities and to each other; discard concepts which are not promising; and detail further definitive analysis or experimental verification required for promising concepts; (4) conduct initial experiments required for verification of promising concepts. The

main objective of the work in generation and stablization of excited states is to perform experimental and theoretical investigations of methods of producing and increasing the lifetime of excited states of helium and other atomic and molecular species in both the superfluid and solid phases of helium. A second objective is to perform experimental and theoretical investigations of producing and stabilizing solid materials containing very high concentrations of hydrogen/deuterium, and also producing and stabilizing solids which have undergone electronic collapse.

W74-70296 **502-04-41**
Langley Research Center, Langley Station, Va.
THE CHEMISTRY AND ATMOSPHERIC INTERACTIONS OF EXHAUST CLOUDS FROM ROCKET VEHICLES
Eugene S. Love 703-827-2893

The objective of this research is to develop a basic understanding of the chemistry of exhaust clouds from rocket vehicles and the interactions of the exhaust clouds with the atmosphere. Although the initial composition of the rocket exhaust is readily approximated by equilibrium calculations, it is of little use in determining the ultimate chemical and physical distribution of these products in the atmosphere, or on the ground. The chemical composition of the exhaust cloud changes continually; rapidly at first as a result of high-temperature reactions with atmospheric species and nucleation of condensible species, and then more slowly as a result of both ordinary and photochemical gas- and condensed-phase reactions, gaseous diffusion, droplet growth and evaporation, and various other interphase and transport phenomena. Thus, a complete chemical characterization of the resulting exhaust cloud as a function of propellant, atmospheric conditions, and time is needed to properly assess the environmental impact of the exhaust products. The results of the research proposed herein will provide a critical part of the technology base required by NASA to develop and substantiate the environmental impact statements for future NASA rocket launches.

W74-70297 **502-04-45**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
SOLID PROPELLANT RESEARCH
Paul J. Meeks 213-354-2546
(502-24-46; 758-56-47)

The overall objective is to acquire scientific bases for the chemical formulation, ballistic and mechanical design of solid propellants for rocket motors operated in the space environment by a combination of complementary theoretical and experimental approaches. Specific objectives are: (1) the prediction of the propellant polymer structure from the properties and proportions of the starting ingredients; (2) the development response during unstable burning; and (4) development and evaluation of a theory of viscoelastic behavior of solid propellants subjected to a generalized stress-time-temperature field.

W74-70298 **502-24-24**
Lewis Research Center, Cleveland, Ohio.
ADVANCED CHEMICAL ROCKET COMPONENT TECHNOLOGY
D. A. Petrash 216-433-6860
(502-24-24; 502-24-37)

The general objectives of the programs conducted under this RTOP are to provide the technology for improvements in performance and reusability of liquid rocket components and subsystems. Experimental and analytical programs will be conducted to develop: (1) low cycle thermal fatigue technology for reusable thrust chambers; (2) improved fabrication techniques for thrust chambers; and (3) reduced gravity fluid acquisition and transfer systems. In the area of thermal fatigue, efforts will be devoted to obtaining fundamental fatigue data, testing materials and designs in an inexpensive thrust chamber simulator and evaluating heat transfer techniques for easing the severity of the problem. For thrust chambers, evaluations will be made of new fabrication techniques and nondestructive testing to determine thrust chamber integrity. Low gravity fluid systems studies will investigate critical characteristics and components for in-orbit fluid acquisition and transfer. Additional efforts will continue with turbomachinery investigations, cavitation and tension in liquids and active POGO suppression. In the feed systems area, valve contamination avoidance is being studied. Design criteria monographs will also be generated.

W74-70299 **502-24-26**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
LONG LIFE ADVANCED PROPULSION SYSTEMS
Paul J. Meeks 213-354-2546
(502-04-20)

The objective of this plan is to provide the system, component and rocket engine technologies required to support advanced propulsion systems that will be used for long duration planetary missions. The overall work includes the development of components and rocket engines and establishing the criteria and technologies required for their integration into advanced chemical propulsion systems. The specific efforts proposed for FY-74 include: studies of long life propulsion systems for use with advanced propellants; testing of a liquid-liquid injection engine utilizing a fluorinated oxidizer and an amine fuel such as FLOX/MMH or F2/N2H4; development of a high precision, fluorine compatible regulator and propellant shutoff valve.

W74-70300 **502-24-31**
Lewis Research Center, Cleveland, Ohio.
ADVANCED LIQUID ROCKET SYSTEMS TECHNOLOGY
J. W. Gregory 213-433-6849
(909-75-03; 502-34-33)

Analytical and experimental efforts are being pursued to provide the technology required for advanced, reusable hydrogen-oxygen space propulsion systems, such as the space tug. The primary effort is aimed at developing the technology for small, high-pressure, reusable, pump-fed, staged-combustion cycle hydrogen-oxygen rocket engines. The work during FY-72 through FY-75 will be concentrated upon critical component technology for a 20,000 lb. thrust engine operating at about 2000 psia chamber pressure. In FY-75, an Experimental Research Engine (ERE) program will be initiated which will extend through FY-78. Critical component technology programs in the turbomachinery and thrust chamber areas will be pursued this fiscal year. In addition, an experimental program will be carried out to demonstrate the technology readiness of a complete space vehicle thermal control system, which allows long term storage of hydrogen in space. Evaluation will be made of the ground hold condition, near earth space hold, and deep space hold. An analytical model of the test configuration will be verified by correlation with the test results.

W74-70301 **502-24-39**
Lewis Research Center, Cleveland, Ohio.
SAFETY RESEARCH
Paul M. Ordin 216-433-6941

The objectives are to obtain a better understanding of the hazards and improve the safety of NASA and contractor operations associated with oxidizer and fuel systems and related cryogenic propellants for flight, R and D facilities and ground service equipment. Standards/criteria recognizing the threat of failures of the oxidizer systems are to be prepared. Initiation of system failures included by chemical and physical properties of oxidizer, oxidizer environment and contaminants will be investigated. A firmer base for risk management techniques related to ground and spacecraft systems will be provided by ASRDI, by conducting or having conducted for it, investigations of combustion, and vapor-air explosions caused by accidental spills of propellants. An analysis of the potential gravity effects on the existing fire extinguishment systems has indicated that gravity effects may reduce the effectiveness of systems as they now exist. A program will be initiated to study the dynamics of extinguishment in normal and zero-gravity. Investigations of the multiphase compressible flow of cryogenic fluids will be continued.

W74-70302 **502-24-41**
Langley Research Center, Langley Station, Va.
ADVANCED PYROTECHNIC/EXPLOSIVE SYSTEMS TECHNOLOGY
Eugene S. Love 703-827-2893

The overall objective is to develop and demonstrate technology

for pyrotechnic systems that is needed to meet aerospace flight program requirements. Experimental programs will be conducted to develop understanding of critical performance parameters at the system level. Systems must demonstrate compatibility of initiation, combustion, energy conversion to mechanical or chemical work, and the actual accomplishment of the desired mechanical/chemical function. Studies will be directed toward validation of aging techniques developed for pyrotechnic and explosive compositions, providing design criteria and experimental demonstration techniques at the levels of basic ingredients and completed components. The effects of ignition and combustion of typical pyrotechnic materials will be investigated at laboratory ambient and cryogenic vacuum conditions. A program will be directed toward the limiting of mechanical shock produced by actuation of pyrotechnic devices using measurement techniques that have been developed to monitor this highly complex environment. New pyrotechnic materials will be studied that exhibit improved resistance to electrostatic voltages, and provide low burn rates to more effectively tailor pyrotechnics to the required mechanical/chemical functions. Non-destructive testing techniques will be developed in the form of low-energy pulses through the initiating element. Pyrotechnic performance monitoring techniques will be developed such as a precision calorimeter and apparatus that simulate actual pyrotechnic operations. The NASA-LRC explosive seam welding technique will be expanded to meet complex aerospace fabrication requirements.

W74-70303 **502-24-46**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
ADVANCED SOLID PROPULSION AND PYROTECHNIC CONCEPTS
Paul J. Meeks 213-354-2546
(502-04-45)

The overall objective is to provide new technology for solid propulsion and pyrotechnics, resulting in improvements (of cost-effectiveness, reliability and/or performance) or new concepts (where existing ones will not meet the mission requirements) to support NASA needs in solid propulsion and pyrotechnics. A combination of complementary analytical and experimental approaches will be taken in the study, design, test, and demonstration of advanced concepts, with the specific approach tailored to the circumstances of the particular work unit. In addition, supporting research and development will be accomplished to provide data and solutions concerning solid rocket operational and design problems. Specific objectives are: (1) to determine methods by which thermal stability of composite propellants can be improved to meet heat sterilization needs and to prepare and study the chemical degradation of new propellant polymers; (2) to understand propellant grain mechanical behavior over the duty cycle in spacecraft applications; (3) to establish the limits of the capability of solid propellants and pyrotechnics to withstand neutron and gamma radiation from RTG's and natural environments and then to age on long term missions; (4) to reduce the cost to spacecraft testing for pyrotechnic shock by a better understanding of pyro shock and by the development of low-shock pyrotechnic devices; (5) to reduce the cost of hot bridgewire squibs by the development of a well-behaved pytrotechnic explosive mix; (6) to apply the solid-state laser advantageously to the ignition of pyrotechnic and explosive devices; (7) to complete the liquid quench termination motor testing and explore the advanced solid-quench concept, (8) to complete---

W74-70304 **502-24-03**
Lewis Research Center, Cleveland, Ohio.
PRIME PROPULSION ION THRUSTER TECHNOLOGY
R. C. Finke 216-433-4000
(502-04-01)

The overall program is directed at applying the knowledge gained from ion thruster research programs to the design, fabrication, and testing of new thruster components; integration of promising new components into thruster sized for widest possible applications, and evaluating thruster performance. Testing of components (thruster, PCU, etc.) as a system to optimize component performance and life testing as part of the system to verify durability will be done. The technology developed will result in hardware for flight prototype thruster subsystems of demonstrated efficiency and durability, thus assuring a firm base of technology-ready hardware for application to anticipated electric propulsion spacecraft. The major program will develop qualified mercury electron bombardment thrusters for high efficiency applications; for instance, synchronous satellite raising mission and 0.1 to 3 a.u. interplanetary missions. Interactions of multithruster clusters are also being investigated. Pertinent information from experimental and analytical studies and demonstrated components will be integrated into a specific thruster system design. This design will cover the widest possible range of currently foreseen mission types. Thruster system interactions and integration problems will be investigated to the extent necessary to clearly define interface problem areas. Effect of power conditioner on thruster performance and dynamics will be studied.

W74-70305 **502-24-04**
Lewis Research Center, Cleveland, Ohio.
AUXILIARY PROPULSION ION THRUSTER TECHNOLOGY
R. C. Finke 216-433-4000
(502-04-03)

The overall program is directed at applying the knowledge gained from ion thruster research programs to the design, fabrication, and testing of new thruster components; integration of promising new components into thrusters sized for widest possible applications and evaluating thruster performance. Testing of components (thruster, PCU, etc.) as a system to optimize component performance and cycle life testing as part of the system to verify durability will be done. The technology developed will result in hardware for flight prototype thruster subsystems of demonstrated efficiency and durability, thus assuring a firm base of technology-ready hardware for application to anticipated auxiliary electric propulsion controlled spacecraft. The major program in this area is to develop this qualified vectorable mercury electron bombardment thruster for low-powered, long-life missions (e.g., north-south station keeping and attitude control of 5- to 10-year geosynchronous satellites.) Endurance tests of thruster systems will be performed in a cycle mode, duplicating the mission profile. Qualified, low-power-consumption vector grid systems will be demonstrated.

W74-70306 **502-24-08**
Goddard Space Flight Center, Greenbelt, Md.
AUXILIARY PROPULSION SYSTEMS FOR APPLICATION SATELLITES
R. A. Callens 301-982-4205

Unmanned meteorological, earth physics, earth observation and other application spacecraft require, not only long lived, light weight auxiliary propulsion systems, but also ones capable of providing north-south station keeping, precession control, east-west station keeping, or precise attitude control. The objective of this RTOP is to identify and develop the auxiliary propulsion systems needed for these spacecraft. When necessary, they are evaluated in either GSFC's Electric Propulsion Laboratory or its Hydrazine Test Facility. Additionally, when necessary, space flight tests of candidate systems are conducted to further demonstrate their capability for space flight application.

W74-70307 **502-24-10**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
SEP SYSTEMS INTEGRATION
Anthony. Briglio, Jr. 213-354-6137
(502-24-05; 502-24-11; 502-25-56)

The broad objective of the integration activities is to provide a continuing technology and integration base in which to focus the solar-electric propulsion thrust subsystem design effort and to reduce flight project risk. In FY-72/73 the SEP module was defined and a preliminary baseline design was documented. As part of the FY-73 activities, preliminary functional descriptions were generated for the computer command and power subsystems, and an updating of the preliminary functional description for the thrust subsystem was completed. In order to establish a more complete technical understanding of the SEP module, the tasks outlined for this fiscal year are to complete the preliminary functional descriptions of the remaining major

subsystem areas which interface with the thrust subsystem and update those preliminary functional descriptions already generated to insure system self-consistency. These newly generated functional descriptions for FY-74 will include attitude control, thermal control, structures, and cabling. The updated functional descriptions will include the thrust, power, and computer command subsystems. In support of the Thrust Subsystem Engineering Model effort (RTOP 502-24-11) the integration activities will begin to identify the propulsion support subsystems which will be required to support the engineering model and the degree of simulation required for its testing. The objectives of this RTOP are consistent with the over-all objective of achieving technology readiness of solar-electric propulsion by the end of FY-78.

W74-70308 **502-24-11**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
SOLAR-ELECTRIC PROPULSION THRUST SUBSYSTEM
Anthony. Briglio, Jr. 213-354-6137
(502-24-05; 502-24-10; 502-25-26)

The major objective of this RTOP is the design and testing of an engineering model of a solar-electric propulsion thrust subsystem. This effort will demonstrate that the thrust subsystem will be compatible with the requirements of a projected initial flight application. Key aspects will include the: (1) functional capabilities; (2) stability; precision; and accuracy of control of the thrust subsystem; (3) adequate characterization of the environment presented by the thrust subsystem; (4) definition of workable interfaces between the thrust subsystem and the key propulsion support subsystems; and (5) documentation of subsystem and element functional requirements. This objective is consistent with the over-all objective of achieving technology readiness of solar-electric propulsion by the end of FY-78.

W74-70309 **502-24-17**
Marshall Space Flight Center, Huntsville, Ala.
SOLAR ARRAY TECHNOLOGY FOR SOLAR ELECTRIC PROPULSION STATE
L. E. Young 205-453-4566
(180-17-57)

The objective of this RTOP is to insure the availability and adequacy of technology to support the solar electric propulsion stage solar array. The approach is to assess the adequacy of existing advanced solar array technology and to use that which is applicable and to develop that which is not. Specifically the GE and Hughes rollup solar array concepts will be considered along with the possibility of a different deployment scheme using the Lockheed deployable boom concept. As a backup approach or possibly a product improvement approach, the FEP teflon solar cell sandwich blanket concept under development by LeRC will be considered. The effort will be accomplished according to a 4 point work breadkown as follows: (1) analysis of technology available in comparison to SEPS requirements; (2) specific technology development; (3) specific application development; (4) fabrication and test of a full scale test article.

W74-70310 **502-24-18**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
PULSED PLASMA THRUSTER SYSTEM TECHNOLOGY DEVELOPMENT
Anthony Briglio, Jr. 213-354-6137

The objective of this program is to continue the development of high-energy, high-total-impulse pulsed plasma thrusters. The principal activities in FY-74 will include: (1) continuation of life testing of Air Force furnished high-energy capacitors started in FY-73, (2) perform state-of-the-art K-film capacitor life tests, (3) investigate plume characteristics and contamination products of a 4.4-millinewton (1-mlb) thruster, (4) perform related system studies. These activities are concentrated on key developmental areas which will lead to the design of a high-energy flight thruster prototype in FY-75.

W74-70311 **502-24-33**
Lewis Research Center, Cleveland, Ohio.
HYDROGEN-OXYGEN AUXILIARY SYSTEMS TECHNOLOGY
J. W. Gregory 216-433-6849
(502-24-31)

The objective is to provide improvements in the technology of auxiliary propulsion systems and components using hydrogen-oxygen propellants. The work is directed primarily toward development of technology for reusable space vehicles, such as the space tug and space shuttle. The work includes advancement in technology of thruster assemblies, and components thereof, as well as studies of complete integrated auxiliary systems. Work on auxiliary propulsion thrusters for the space shuttle, initiated in previous years, will be continued and brought to conclusion this fiscal year. This effort includes investigation of complete gaseous hydrogen-gaseous oxygen thruster assemblies to determine performance and life characteristics, evaluation of thermal fatigue life of thrust chambers, and extension of thruster operation into the regime of gas/liquid and liquid/liquid propellants with the attendant problems of ignition, stability, and pulsing performance. This work is being done using thrusters of 1000-1500 pounds thrust operating at chamber pressures of 300-500 psia. Auxiliary propulsion thrusters will be investigated at the operating conditions suitable for the space tug, i.e., 30-100 pounds thrust and chamber pressure of 100-200 psia. Evaluation will be made of steady-state and pulsing performance levels, thrust chamber cooling, injector design, and igniter design and operation. Studies will be made of the complete integrated auxiliary systems for the space tug, which includes auxiliary propulsion, pressurization, fuel cell propellant supply, and main feedline chilldown.

W74-70312 **502-05-50**
Lewis Research Center, Cleveland, Ohio.
SOLAR CELLS BASIC RESEARCH
D. T. Bernatowicz 216-433-4000
(502-25-52)

The objective of this work is to raise the efficiency of silicon solar cells so that cost benefits might be realized for space and terrestrial applications. The approach is to find, understand, and eliminate losses associated with recombination centers, surface states, and carrier diffusion processes. The experimental work will be analyzed and correlated with models through computer programs.

W74-70313 **502-05-51**
Lewis Research Center, Cleveland, Ohio.
ELECTROCHEMICAL RESEARCH
H. J. Schwartz 216-433-6910
(502-25-53)

In order to increase the life and performance of electrochemical power systems, and therefore to reduce their cost, a broad research effort is required. The use of inorganic separators in alkaline batteries have significantly increased the life of the silver-zinc battery. A study of the structure and operating mechanism of this separator will permit establishment of manufacturing process controls and can point the way to improved compositions. Solid ionic conductors would be ideal separators. A research program will be continued to identify and evaluate potentially useful compounds. Candidate materials will be synthesized in pure form and evaluated. Emphasis will be on alkali metal and halide ion conductors. Fuel cell research will emphasize basic heat and mass transport studies and catalyst research. The latter work will include studies of alloy catalysts, evaluation of perovskites as oxygen electrode catalysts and preparation of special catalysts by Lewis's electron irradiation method.

W74-70314 **502-05-54**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
PLANETARY SOLAR POWER RESEARCH
Anthony Briglio, Jr. 213-354-6137
(502-25-56)

The objectives of the silicon research program are to develop reliable analytical measurements to characterize bulk properties of semiconducting materials as it becomes available, such as silicon ribbon or thin-film semiconductors, and to improve solar cell efficiency, particularly in lower resistivity cells, by determining the background cause of excess junction current due to space-charge recombination. Techniques will be developed to obtain doping amounts, doping uniformity, and minority carrier

lifetime from simple Schottky barrier measurements. Thermally stimulated currents and capacitances will be measured on cooled-down reversed biased solar cells in an attempt to determine energy levels and densities of recombination centers in the space-charge region. The objectives of the inversion layer solar cell are to determine the feasibility of forming a depletion layer barrier by induced inversion rather than by impurity diffusion, and to investigate the physics of the surface states responsible for the inversion. Cells are being fabricated at University of Arizona with emphasis on transparent electro-SiO2-Si cells. Spectral response and response at various laser wavelengths will be measured with varying intensity which, with electrical measure ments, will provide information about the interface surface states causing the inversion.

W74-70315 **502-05-55**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
ELECTROCHEMICAL ENERGY STORAGE RESEARCH
Anthony Briglio, Jr. 213-354-6137
(502-25-57)

The objectives of this task is to improve battery performance for spacecraft as well as for terrestrial use. This is to be accomplished through a continuing research effort, the major activity of which is the investigation of pulse charging effects on battery performance. Most batteries exhibit performance problems which can be linked to capacity decline, gassing or dendrite formation. Preliminary results of pulse charging experiments and the literature indicate that pulse charging has the potential for improving battery performance in this area. It is anticipated that improved charging and maintenance methods for batteries will directly support long-term space missions as well as terrestrial battery applications. The immediate objectives are: (1) to determine the effects of pulse charging on degradative changes in alkaline cells; (2) to develop pulse charging procedures to extend the life of spacecraft batteries; (3) to define the interfaces imposed by integration of pulse charging systems on spacecraft. The elements of this task will be accomplished by: (1) the determination of the effects of pulse charging techniques on the gassing behavior of sealed nickel cadmium cells; (2) the determination of the effects of pulse charging on the formation and propagation of dendritic growths on zinc and cadmium electrodes; (3) the development of optimum pulse charging techniques for extending the useful lives of spacecraft batteries.

W74-70316 **502-25-52**
Lewis Research Center, Cleveland, Ohio.
SOLAR CELL TECHNOLOGY
D. T. Bernatowicz 216-433-4000
(502-05-50)

The objective is to reduce the cost of solar cells and arrays for space and terrestrial applications. The approach will involve development in four areas: (1) Integration of recent technology advances into practical cell fabrication processes; feasibility study of epijunction cells; application of research advances to the fabrication of high efficiency low resistivity cells. (2) Low cost preparation of single crystal silicon; feasibility of deposited polycrystalline cells; simplified methods of cell fabrication. (3) Continued development of large modules with conventional cells; incorporation of further labor saving innovations such as wrap-around cells and printed interconnects. (4) FEP-covered cells and modules will be flown to demonstrate space worthiness.

W74-70317 **502-25-53**
Lewis Research Center, Cleveland, Ohio.
ELECTROCHEMICAL TECHNOLOGY
H. J. Schwartz 216-433-6910
(502-05-51)

Solar/chemical power systems will continue to dominate the space power field in the years to come. In order to achieve maximum performance at minimum cost, technology is required in several areas. Incorporation of inorganic separators into alkaline batteries will substantially increase their life. Spin-offs of this work can be applied to many terrestrial problems requiring portable power. Work on high energy density batteries based on solid ionic conductors will lead to light batteries with increased efficiency. These will not only find use in satellites but may be used for bulk power storage or electric vehicles. Fuel cell technology work will be directed toward understanding the mechanisms which effect fuel cell life, and therefore control the cost of fuel cell power.

W74-70318 **502-25-56**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
PLANETARY SOLAR POWER TECHNOLOGY
Anthony Briglio, Jr. 213-354-6137
(502-05-54)

The JPL FY-74 Program for planetary solar arrays and solar cell technology development has the following major objectives: (1) continue the 110 W/Kg Solar Array Development Program; (2) continue the development of .01 cm thick high efficiency solar cells; (3) continue the development of improved solar cell fabrication techniques through: the development of silicon ribbon technology, and the evaluation of silane silicon for cell manufacture; (4) continue the development of low cost solar array technology through: evaluation of low-cost module development; and development of standardized engineering design information; (5) qualify the violet cell for deep space application; (6) continue the program to test and evaluate solar cells for deep space application; and (7) develop space solar cell standards for evaluating new solar cell designs. This work will be accomplished through combined in-house and contracted efforts with industry and universities. Special consideration in the approach to meeting these objectives will be given to the mission requirements of the solar-electric propulsion effort.

W74-70319 **502-25-57**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
DEEP SPACE BATTERIES
Anthony Briglio, Jr. 213-354-6137
(502-05-55)

This RTOP is directed toward providing the battery technology to support future planetary missions and terrestrial applications. The objectives are: (1) the development of batteries for long-life (3 to 12 years) planetary missions; (2) the definition and resolution of the interfaces consequent from the integration of long-life battery systems in spacecraft; (3) the continued investigations and development of batteries which are required in order to improve the performance of battery systems for selected short-term (less than 3 years) space missions; and (4) the identification and development of battery and component designs which will reduce cost on a technically sound basis. The objectives are based upon the fact that no battery system is presently available which will reliably support long-life missions, such as Jupiter orbiter, Jupiter entry probe, and outer planet missions. Planetary probe missions also impose sterilization requirements on the battery system. These requirements must be met without sacrificing reliability. Improvements in battery performance and reliability should also be obtained by cost effective means for short-life missions; such as those to Mars, Venus, Mercury, and the comets. This task will be accomplished by: (1) the development of suitable and reliable components, designs, and fabrication techniques; (2) the investigations of the effects of particular environmental conditions on batteries; and (3) the securing and evaluation of data from characterization tests of the components, batteries, and battery systems. The subtasks titled Development of Non-Gassing Batteries, and Mission-Dependent Battery Developments and Evaluations are structured to achieve the program objectives.

W74-70320 **502-25-58**
Goddard Space Flight Center, Greenbelt, Md.
BATTERY QUALITY CONTROL AND TESTS
Thomas J. Hennigan 301-982-5547

This RTOP covers: (1) advance battery material development; (2) increase the usable energy density of nickel-cadmium cells; (3) improve cell and cell component characterization methods and cell fabrication process control; (4) develop analytical methods for cell component analysis; and (5) maintain a NASA test facility to perform battery life tests and investigate methods of accelerated testing.

W74-70321 **502-25-70**
Lewis Research Center, Cleveland, Ohio.
ADVANCED LOW COST POWER PROCESSING AND DISTRIBUTION TECHNOLOGY
Pierre A. Thollot 216-433-4000
(502-25-71)

The objectives of this program are to advance the state-of-the-art and establish the technology required to improve spacecraft and terrestrial power processing and distribution systems. Addressed are, improvements in electrical circuit performance, and the general optimization of power processing and distribution systems including utilization of integral solar array power regulation and conditioning. In addition to general technology this program has as an objective directed technology for specific applications. Included in this category are: power processing concepts with efficiencies in excess of 90% and power densities of about 2.5 Kg/Kw for ion thrusters and single and multi-module power conditioning units meeting low cost, reusable space station-base and shuttle requirements. Also included in this program is an effort directed toward developing engineering tools, using modeling and analysis techniques, which will enable designers to rapidly and accurately assess total system interaction and trade-off effects. Contract and in-house studies, experimental investigation, and hardware fabrication as required to establish the technology of new circuits and power processing and distribution systems for manned and unmanned spacecraft and terrestrial applications.

W74-70322 **502-25-71**
Lewis Research Center, Cleveland, Ohio.
HIGH PERFORMANCE POWER ELECTRONIC COMPONENTS
Pierre A. Thollot 216-433-4000
(502-25-70)

The objectives of this program are to advance the state-of-the-art and establish the technology required to improve electronic power components and subsystems and to investigate interactions between the electrical systems and the environment of spacecraft. This includes the development of improved electronic power components as required for use in low weight, high efficiency power processors and distribution systems. It also includes the interaction effect of high voltage and construction materials with space environments, including plasma, solar illumination, low temperature, and vacuum. Space station-base and shuttle flight programs, satellites for survey, scientific and communication purposed. Contract and in-house studies, experimental investigations and hardware fabrication as required to establish the technology of new components and to investigate the electrical space environmental interactions of materials used in spacecraft construction.

W74-70323 **502-25-72**
Goddard Space Flight Center, Greenbelt, Md.
POWER PROCESSING FOR EARTH ORBITAL SPACE SCIENCE AND APPLICATIONS SATELLITES
Edward R. Posciutti 301-982-4885

Research objects are: (1) power conditioning investigative techniques and developments to improve power conversion efficiencies, reliability, and performance: (2) to investigate input/output transient problem areas and solutions; (3) establish library of computer design programs for design and analysis of power conditioning systems and subsystems, to effect improved efficiency, utilization and lower cost through standardization.

W74-70324 **502-25-73**
Marshall Space Flight Center, Huntsville, Ala.
MULTI-KW DC DISTRIBUTION SYSTEM TECHNOLOGY
J. L. Felch 205-453-4631
(113-60-21)

The program proposed constitutes a supplemental effort to the Space Vehicle Electrical Power Processing, Distribution and Control Study performed by TRW under NASA/MSFC contract NAS8-26270 (RTOP 113-60-21) and utilizes the results and detailed study procedures developed as a part of that program. This study disclosed that major improvements in weight, power losses, reliability, and flexibility can be obtained by the use of DC power distribution in excess of 100 volts. A flexible and cost effective technology test capability of the detailed performance characteristics, technology readiness, and advantages or disadvantages of a multi-KW DC distribution system will be developed at MSFC.

W74-70325 **502-25-74**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
LONG-LIFE, HIGH-PERFORMANCE POWER PROCESSING FOR PLANETARY APPLICATIONS
Anthony Briglio, Jr. 213-354-6137

The major objective of this RTOP is to develop and demonstrate power processing and distribution and related system configuration and integration technology to meet the requirements of future planetary spacecraft. These requirements include longer life, higher performance and higher reliability than can be achieved with existing technology. The intent of this work is to develop designs that not only can meet the technical requirements but which can also be built and incorporated into the spacecraft power system for minimum cost. In developing the necessary capability, techniques and hardware it is required that the specialized requirements of both solar and sun-independent power sources be accommodated. Also, a significant capability for automated power systems operation is a likely requirement for many future planetary spacecraft. The basic approach being taken to meet the objectives of the RTOP is to develop modular or building block designs of the major power processing elements within the spacecraft power system. These designs are standardized to the maximum extent possible and feature cooperative rather than standby redundancy. This minimizes the total number of separate modules required in the system and, hence, the cost to build and test it. High-performance circuits are used throughout and the basic approach offers a large degree of flexibility of scaling the system to different input voltages and power levels. Additionally, standardized design and analysis methods are being developed and applied for all power processing circuits used in planetary spacecraft power systems. Finally, test methodology and equipment for multi-redundant power systems is being developed, and initial investigations into providing automated power system management are being conducted.

W74-70326 **502-25-80**
Goddard Space Flight Center, Greenbelt, Md.
HIGH EFFICIENCY SOLAR CELL DEVELOPMENT AND EVALUATION
Luther W. Slifer, Jr. 301-982-4841

The objective is to: development of high efficiency solar cells into production line items, and evaluation of production line cells for space flight use. The general approach will: (1) evaluate pilot line samples of high efficiency cells; (2) transfer technology to production line; (3) evaluate production progress samples; (4) flight qualify production cells; (5) develop large area production cells; (6) develop thin production cells; (7) perform yield and cost analysis; (8) develop detailed production procedures; (9) develop quality assurance requirements; and (10) develop high efficiency solar cell specification.

W74-70327 **502-25-90**
Lewis Research Center, Cleveland, Ohio.
THERMO-MECHANICAL ENERGY CONVERSION
D. R. Packe 216-433-4000

This RTOP provides the technology for high-efficiency, long-life thermo-mechanical space power conversion systems applicable to near-term NASA missions. This will cover a demonstration of the Brayton power conversion process in the fractional-to-2 kilowatt power level as well as a study of alternative conversion processes especially for fractional kilowatt output. NASA missions in the late 70's and early 80's appear to require power levels in the neighborhood of 1 kilowatt. Several of these missions, especially deep space probes, cannot use solar arrays. In addition, certain DOD missions in this time period require compact power systems with long-life and in the range of 1 kilowatt power output. To fulfill these needs especially to provide confidence for mission selection, a proof-of-concept Brayton conversion system will be designed, built, and run to demonstrate failure-free and unattended operation for a continuous period of at least two years.

W74-70328 **502-35-60**
Lewis Research Center, Cleveland, Ohio.
HYDROGEN-OXYGEN POWER SYSTEMS
D. G. Beremand 216-433-6366

The objectives are to develop technology readiness for a hydrogen-oxygen APU to provide hydraulic and electric power for the space shuttle vehicle, and to evaluate the performance potential and applicability of hydrogen-oxygen dynamic power systems for other space and ground applications. Detail analysis, design, fabrication, and test of a 400 HP test APU supplied with high-pressure liquid or gaseous propellants is being conducted under Contract NAS3-15708 by AiResearch. The primary technology area under investigation involves the system dynamic controls in the propellant feed and conditioning subsystem. This effort includes development of a system computer model to permit ready evaluation of system modifications and parametric changes as required for final application. A unit will be delivered the last half of 1974. In-house effort will be used to provide conceptual designs (weight and volume) of H2-O2 supply systems. Evaluation tests of a positive displacement liquid hydrogen pump, which would be required for a low pressure liquid supply system, are being performed under contract. Conceptual design studies will be performed in-house to evaluate the performance potential of hydrogen-oxygen power systems and to determine the applicability of such power systems for applications such as sortie module experiments, high rate data transmission in space, ground transportation, and stationary power.

W74-70329 **502-35-62**
Lewis Research Center, Cleveland, Ohio.
TERRESTRIAL APPLICATIONS OF SOLAR ENERGY
F. E. Rom 216-433-6266

The purpose of the Terrestrial Applications of Solar Energy Program is to investigate practical, economical, and socially acceptable systems utilizing solar and solar-derived energy sources. Solar energy represents a clean, nondepleting energy source that can be utilized to help meet our nation's growing energy needs. The program consists of investigating systems utilizing solar energy for generating electricity, heating and cooling buildings, and producing clean fuel.

W74-70330 **502-07-01**
Ames Research Center, Moffett Field, Calif.
GAS DYNAMICS RESEARCH
Glen Goodwin 415-965-5065
(502-27-01; 502-27-02)

The objective is to acquire a basic understanding of the characteristics of high-energy fluid flows and related aerothermodynamic phenomena so as to be able to identify and understand potential problems relevant to long lead time NASA mission requirements. To utilize the best analytical and experimental methods available to determine basic thermodynamic and transport properties of gases, kinetic rate processes in gases, and radiative transfer in gases. To develop and experimentally verify computer codes that numerically simulate the complete three-dimensional flow field about entry vehicles for conditions duplicating entry trajectories. Classical, semi-classical and quantum theories will be used, as appropriate, to determine basic thermodynamic, kinetic, and radiative properties of gases needed for high-energy fluid flow problems, and particularly to include three-dimensional collision effects wherever possible. The theoretical results will be validated with selected experiments. The first flow field experiment will be that of an axisymmetric shock-wave-expansion interaction with an hypersonic turbulent boundary layer. The computer code planned is the complete solution of the Navier-Stokes equations including various models for the turbulent transport terms. The Monte Carlo statistical approach will be used to calculate transient effects in rarefied gases that are normally obtained from approximate solutions to the Boltzmann equation. The parallel processing features of the Illiac will be used to obtain solutions for larger sample populations in more dense gas than heretofore possible in a reasonable computing time.

W74-70331 **502-07-01**
Langley Research Center, Langley Station, Va.
GAS DYNAMICS RESEARCH
Eugene S. Love 703-827-2893
(502-27-01; 502-27-02; 502-37-01)

The objective of this work is to acquire a basic understanding of the characteristics of high energy fluid flows and related aerothermodynamic phenomena leading to improved design capability for future aerospace vehicles during vehicle exit and/or entry into the atmospheres of the earth and planets. The objective will be pursued using analytical and experimental methods and will be conducted in-house. Studies to be conducted during the current fiscal year include: (1) computer simulation of shock and expansion tube flows; (2) shock tube measurements of electron density distributions ahead of and behind strong shock waves in various gases, (3) determination of real gas nonequilibrium effects in hypersonic viscous flows; and (4) production of ultra-high temperatures (up to about 40,000 K) in xenon and krypton as test gases to evaluate the use of such gases as heat baths for gas kinetics and radiative properties investigations.

W74-70332 **502-27-02**
Langley Research Center, Langley Station, Va.
ADVANCED EARTH-ORBITAL TRANSPORTATION TECHNOLOGY
Eugene S. Love 703-827-2893

The objective of this study is to identify and develop the aerothermodynamic technology required for the design and operation of advanced earth-orbital vehicle systems suitable for space operations or global transportation in the late 1980's and beyond. The intent is to derive viable concepts which build upon the technology base developed under the Space Shuttle Program, and the predicted advances within this decade in materials and structures, as well as potential gains in such areas as propulsion efficiency. Such concepts should offer significant advantages in the areas of performance, heat transfer, and flying qualities. A primary output will be the identification of technology areas requiring focused attention to permit achievement of advanced transportation goals. Operational limitations imposed by various constraints such as environmental considerations will be examined. Candidate concepts will be evaluated through a series of trade-off analyses and parallel experimental investigations. Analytical efforts will include the development of methods for vehicle characteristics definition, such as the methodology for flow field calculation, and the means to objectively assess the value of technology improvements. A highly efficient aerospace transportation system is a potential major thrust for the agency and the nation in the 1980's. The concept is sufficiently challenging and broad to insure continued expansion of the national technological base while being sufficiently utilitarian to gain support. Studies of various approaches should evolve a sound basis for a research vehicle concept for the late 1970's leading in turn to a viable operational system capability in the post 1980 time period.

W74-70333 **502-27-02**
Ames Research Center, Moffett Field, Calif.
ADVANCED EARTH-ORBITAL TRANSPORTATION TECHNOLOGY
Glen Goodwin 415-965-5065

The objective is to develop the aerodynamic and heat protection technology required for design of advanced earth-orbital spacecraft for the late 1980s. Under aerothermodynamics, analytical and/or semi-empirical techniques will be developed for the prediction of the lee-side heating rates for typical entry vehicles. Data will be obtained in the 3.5 foot Hypersonic Wind Tunnel to ascertain the effect of flow parameters (e.g., Mach and Reynolds number, whether the windward boundary layer is laminar, transitional or turbulent) and geometric parameters (planform, nose bluntness) on the lee-ward flow. These data will be used to generate or verify these prediction techniques. In addition, data on a new basic entry configuration will be investigated which is more amenable for verifying the inviscid-viscous computer codes which are being developed. The objective in the heat protection area is to study and evaluate concepts for reusable thermal protection of advanced earth-orbital and tug spacecraft. Advanced thermal protection systems for tug

vehicles will be the initial focus. Specific objectives will be failsafe capability, low-weight and cost, and on-orbit inspectability for re-flight certification. The study will be both analytical and experimental and will be carried out in-house. The requirements for the tug TPS will be utilized in the early concepts considered. These concepts will then be evaluated under realistic tug simulations in the Ames high-enthalpy arc heaters.

W74-70334 **502-27-03**
Langley Research Center, Langley Station, Va.
ADVANCED EARTH ORBITAL TRANSPORTATION - TPS TECHNOLOGY
George W. Brooks 703-827-2042

The objective of this research is to devise and evaluate new or improved concepts of thermal protection systems for advanced earth orbital reentry vehicles. In particular this effort will focus on development of systems based on reliable metallic heat shields. Effects of oxidation, vaporization, and solid state diffusion on the service life and performance of metals and coatings will be determined. Analytical models for both high and low temperature insulation systems, considering all significant modes of heat transfer, will be developed. Heat transfer will be determined in the vicinity of flow disturbance such as shock intersections and joints between heat shield panels, and materials characteristics required to accommodate these high local heating rates will be defined. Tests to verify all of these studies will be conducted with large scale models.

W74-70335 **502-27-01**
Ames Research Center, Moffett Field, Calif.
PLANETARY ENTRY TECHNOLOGY
Glen Goodwin 415-965-5065
(502-07-01)

The objective is to develop the aerothermodynamic and ablative-heat-protection technology required to design spacecraft for entry into Venus and the outer planets, and to evaluate heat shield design concepts for future space-exploration vehicles capable of entering atmospheres at speeds to 60 km/sec. The work includes aerothermodynamic studies; to define the heating environments to be encountered; to minimize the heating rates and total heat loads by proper choice of trajectory, vehicle shape, and heat shield material; to evaluate available materials in simulated environments including a number of different atmospheric compositions and combined convective and radiative and convective heating loads; to develop new materials tailored to prove maximum heat protection in given environments. In a cooperative program with JPL, shock tube measurements of radiative emission, radiative cooling, and ionization equilibration time will be performed for hydrogen and hydrogen-helium mixtures at speeds to 50 km/sec and pressures to one atmosphere duplicating the conditions of interest for entry into the outer planets. Heat shield materials capable of the severe entry conditions of the outer planets will be tested in arc jets and their performance evaluated. A comprehensive realistic description of the gas cap radiation environment coupled to the material response for graphitic, reflecting and transpiration cooled heat shields will be performed by carrying out computations on the Illiac computer. Proof of concept for reflecting heat shields has been demonstrated for teflon, boron nitride, and silica/silica. Development of more efficient reflecting heat shields will continue.

W74-70336 **502-27-01**
Langley Research Center, Langley Station, Va.
PLANETARY ENTRY TECHNOLOGY
Eugene S. Love 703-827-2893
(502-07-01)

The objective is to establish the technology base necessary to assure survival and reliable performance of scientific probes during entry into the atmospheres of Mars, Venus, and the outer planets. The technology readiness target schedule, which assumes a cutoff in technology development 3 years prior to launch, is 1974 for Venus, 1977 for Saturn and Uranus, and 1981 for Jupiter. This target schedule is the key for the specific task milestones. The objective will be pursued using analytical and experimental methods and will be conducted primarily in-house with contract support as justified. This work will encompass the following topics: (1) Studies to: define hypervelocity earth and other planetary entry vehicle heating and aerodynamic environments, and minimize radiative and convective heating and/or heat loads and optimize aerodynamic performance by choice of trajectory, vehicle shape, etc. (2) Development of aerothermodynamic technology required for upgrading of existing facilities or design of new facilities considered appropriate to development of planetary entry aerothermodynamic technology.

W74-70337 **502-27-01**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
PLANETARY ENTRY TECHNOLOGY
Rob R. McDonald 213-354-6186

Since the outer planets have atmospheres consisting mainly of hydrogen and helium, the work performed in this plan is applicable to entry to either Saturn, Uranus, Jupiter, or Neptune. Only the speed of entry differs for the several planets since it is proportional to the mass of the planet. The objectives of this plan are to calculate and measure the radiative properties of the shock heated gas found in the outer planet atmospheres, to establish a method where the effect of laminar-turbulent transition and base flow on heat transfer to an entry probe can be determined, to develop and provide physically sound methods and schemes for computing the flow field, energy fluxes and vaporization rates for outer planet entry probes, and to develop laboratory shock tube facilities for the purpose of studying heat transfer problems. In fulfilling these objectives we will measure equilibrium radiative intensity and the radiation relaxation time behind shock waves in outer planet atmospheric gases at the highest achievable speeds in conicial arc shock tubes. To obtain better agreement with data, theoretical modeling of the ionization scheme will be continued. Measurements of convective heat transfer to blunt entry probe models will be made at high Reynolds in the shock tube. These measurements of heat transfer at laminar, transition, and turbulent boundary layer conditions will be used to further refine a numerical method capable of estimating entry heat transfer rates for planetary entry probes. *Studies are underway to incorporate the finite-rate kinetics with* simplified flow-field analysis to yield optimum shapes of Saturn and Uranus entry probes with corresponding entry angles, such that their heat shields will be the lightest.

W74-70338 **502-27-04**
Langley Research Center, Langley Station, Va.
PLANETARY ENTRY TPS TECHNOLOGY
George W. Brooks 703-827-2042

The objectives of this research are: (1) to evaluate heat shield materials, concepts, and theories which have potential application to planetary missions; (2) to develop those analyses of environmental inputs and environment - heat shield interaction which are necessary to conduct heat shield studies; (3) to develop and improve entry simulation facilities to provide in-house support for planetary programs; and (4) to determine thermal protection system requirements for future planetary missions. Theoretical analyses will be developed of the heat inputs to an ablating surface under planetary entry conditions. Heat shield materials response to high radiant heating will be determined, and the relative importance of energy absorption, reflection, and transmission will be evaluated. Mechanisms which explain new or existing experimental materials performance data will be developed. New methods for simulating planetary entry heating will be explored, and available facilities will be used to evaluate materials and verify ablation mechanisms. Heat shield requirements for various vehicle configurations and different planets will be calculated.

W74-70339 **502-37-01**
Ames Research Center, Moffett Field, Calif.
SPACE SHUTTLE: CONFIGURATIONS AND AEROTHERMODYNAMICS
Glen Goodwin 415-965-5065

The objectives are: (1) to evaluate the aerodynamic performance, stability and control, heating, and sonic boom overpressures of the space shuttle orbiter and launch configuration; (2) to determine the effects of shuttle launch and reentry on the chemistry of the upper atmosphere; and (3) to pinpoint and

find the solution to aerothermodynamic problems of these vehicles in support of the Phase C/D studies. Accordingly, models resulting from contractor and in-house studies will be tested in subsonic, transonic, supersonic, and hypersonic facilities of the Ames Research Center. Shadowgraph and oil-flow photographs, flow field pressure surveys, heat transfer, and static aerodynamic data will be obtained. The wind tunnel and trajectory data will be used to evaluate the space shuttle characteristics relative to existing airplanes and entry vehicles such as lifting bodies. The effects of realistic gaps, joints, and surface conditions on boundary layer transition and heat transfer will be determined. Numerical methods and computer programs will be developed for calculating the three-dimensional chemical-nonequilibrium viscid and viscous real gas flow around space shuttle orbiter configurations at angle of attack and for calculating the thermochemical response of the upper mesosphere to shuttle launch and entry. Near-field pressure signatures of proposed shuttle configurations will be obtained in appropriate ground-based test facilities and techniques for extrapolating the results to ground-level will be developed.

W74-70340 **502-37-01**
Langley Research Center, Langley Station, Va.
SPACE SHUTTLE AEROTHERMODYNAMICS, CONFIGURATIONS, AND OPERATIONAL ANALYSIS STUDIES
Eugene S. Love 703-827-2893

This RTOP focuses Langley's expertise in configuration aerothermodynamics and operational flight mechanics on those concerns having greatest impact on successful development of the shuttle. The RTOP supports the shuttle program by (1) providing time in Langley ground-based facilities for direct OMSF/contractor-requested support, (2) continuing independent in-house shuttle technology and development studies, (3) responding to specifically requested task-study areas from the Program Office at JSC, and (4) maintaining a strong basic aerothermodynamic supporting technology program. In addition, Langley will perform independent evaluations and assessments of the configurations and operational modes and requirements as necessary. This RTOP program is coordinated with other NASA centers and the Phase C/D contractor through appropriate Program Office Engineering Coordination Panels at JSC.

W74-70341 **502-37-02**
Langley Research Center, Langley Station, Va.
SPACE SHUTTLE THERMAL PROTECTION SYSTEMS
George W. Brooks 703-827-2042

The objective is to investigate thermal protection systems for the space shuttle in order to: (1) assess the adequacy of existing technology, (2) identify and implement programs required to establish a firm technology base, (3) provide TPS testing in LRC arc-jet facilities in support of the space shuttle program, and (4) develop instrumentation which will accurately measure surface temperatures and emittances of TPS materials. Three basic classes of heat shields are being investigated: low-cost ablators, reusable surface insulators, and metallic radiators. Parametric studies will be made to provide rational and up-to-date estimates of the weight and cost of heat shields. Large-scale models will be designed, fabricated, and tested to validate analytical results and prototype designs. Results of these studies will serve as a basis for selection and design of shuttle thermal protection systems. Facility modifications, being made under C of F Project No. 2389, will provide improved testing capability for the work to be done under this RTOP.

W74-70342 **502-37-02**
Ames Research Center, Moffett Field, Calif.
SPACE SHUTTLE THERMAL PROTECTION SYSTEMS
Glen Goodwin 415-965-5065
(502-27-02; 502-31-50)

The performance (including reusability) of candidate heat-shield materials and configurations will be evaluated and failure modes and material modifications identified that would increase the performance potential. Immediate objectives for FY-74 include continued evaluations of the performance of reusable surface insulations (RSI), performance of joints and defected panels, and the performance of coated carbon-carbon composites. Samples of heat shield materials will be exposed to electric arc heated supersonic air stream. RSI and carbon-carbon materials will continue to be tested in the laminar stagnation area of models at conditions producing the expected flight temperatures under laminar boundary layer flow. Also, flat material samples will be tested in the Ames 1 x 5 and 2 x 9-inch supersonic, turbulent flow ducts. Samples will be mounted so that the thermal characteristics of the structure will be simulated, and thermocouples will be installed in appropriate locations in order to ascertain the thermal performance. TPS tile joint configurations and attachment techniques will be evaluated as well as simulated defects in the tiles in tests in the Interaction Heat Shuttle Panel Test Facility. System conditions and duration of exposure to the flow will be varied to simulate as closely as possible the expected reentry conditions appropriate to the tests being performed. Models will be subjected to repeated tests to determine their ability to withstand multiple reuse.

W74-70343 **502-37-03**
Flight Research Center, Edwards, Calif.
SHUTTLE SYSTEMS AIRPLANE FEASIBILITY STUDY
Jack L. Kolf 805-258-3311

The present space shuttle operational concept involves flying the obiter from manufacturing and recovery sites to the launch area at either Cape Kennedy or Vandenberg AFB using a ferry kit. The use of this proposed ferry kit presents areas of concern related to the logistics and time involved in the installation of the kit, the many stops due to limited range during the cross country flights, and removal of the kit before orbital flight. The purpose of this proposed study will be primarily to examine an alternate approach to the ferry mission through the use of a ferry aircraft which would also be configured for transporting other major vehicle components such as the external tank, recovered boosters, or solid rocket segments. Two studies by major aircraft companies are proposed which will investigate the feasibility of accomplishing this task by either modifying an existing airplane (747/C-54 class) or developing a simplified configuration which would utilize a maximum of off-the-shelf hardware, engines, and airplane components. In addition to the above, the contractors will be asked to consider the possibility of air launching the orbiter from the ferry airplane during the horizontal flight test program. This approach will provide a more compatible configuration for testing with that returning from orbit and enable a more comprehensive test program to be conducted.

W74-70344 **502-03-11**
Goddard Space Flight Center, Greenbelt, Md.
LASER PHYSICS
H. H. Plotkin 301-982-6171
(502-23-15; 161-05-02)

The overall objective is to perform fundamental theoretical and experimental research in the physics of quantum electronics, lasers, masers, and related devices, and in the areas of their application which are particularly related to NASA's interests. The work is performed under grants to four universities, and the requirements and resulting information are coordinated and disseminated among all relevant Centers and elements of NASA. Subjects to be investigated in FY-74 will include study of new laser molecules and excitation processes, means for stabilizing lasers, production and transmission properties of ultrashort pulses, infrared mixers and rectifiers, theory of high pressure and high power lasers, and laser spectroscopy of astronomical sources. The results are required in on-going NASA programs and to advance technology needed for optical space communication, earth and ocean dynamics studies, earth observations, astrophysics, power generation and transfer, and materials studies.

W74-70345 **502-03-12**
National Aeronautics and Space Administration, Washington, D.C.
OPTICAL COMMUNICATION RESEARCH
H. L. Anderton 202-755-2450
(502-03-11; 502-23-15; 502-23-18)

This program of research is directed towards providing NASA with fundamental tools and methods of optical communication at earth orbital and interplanetary distances for missions in the

1975-1985 time period. The future requirements for high data rate communication may well be satisified by optical communication systems using laser technology. This program will advance optical technology by means of two grants for research in laser transmitters, modulators, receivers and optimal communication techniques, and will complement related research and development at NASA field Centers.

W74-70346 **502-03-31**
National Aeronautics and Space Administration, Washington, D.C.
ARTIFICIAL INTELLIGENCE
C. E. Pontious 202-755-2440
(502-03-32)

The objective of this RTOP is to improve our ability to manage large amounts of data, to effectively utilize sensed information, and to provide more efficient methods for processing information. Near term targets include development of automated problem-solving systems and techniques for machine perception and analysis of scenes. The technical approach is to develop computer models which simulate intelligent system operations such as perception, question-answering and learning and test these models with various real or approximately real functional problems. The results will provide guidelines for the development and exercise of autonomous or robotic systems such as the JPL robot 'rover' project. The work will be performed through a series of research grants and contracts with academic and industrial laboratories recognized for their competency in automated information systems R and D.

W74-70347 **502-03-32**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
ARTIFICIAL INTELLIGENCE FOR INTEGRATED ROBOT SYSTEMS
Robert V. Powell 213-354-6586

The long-range objective of this RTOP is to make a significant contribution to NASA strength in robotics, so that when missions to planetary bodies require adaptive, semiautonomous machines, the necessary conceptual tools and approaches will be available and demonstrable. This goal will be approached through research on how machines should be structured to perform meaningful scientific and operational tasks in a complex, perceptually rich, dynamic environment. The immediate objective is to design, construct, and put into operation, by July 1975, an integrated breadboard robot system that can be used in subsequent research as a tool for developing, testing, and displaying concepts of robot system design and operation, and of machine intelligence. This objective will ensure that the program is sharply focused on problems germane to the long-range interests of NASA and its planetary program. The robot breadboard for July '75 will be designed for functions typical of a roving vehicle on the surface of Mars. The primary tasks will be to provide the necessary sensory and motor capabilities, and to integrate these into a well-coordinated system by means of suitably structured software. Specific objectives for FY-74 are: (1) complete development of all subsystem hardware except for the vehicle; (2) acquire and put into operation the dedicated computing system needed for real-time control of the hardware and connect it to the ARPA net through the USC Terminal Interface Processor; (3) interface the subsystem hardware with the computer and verify their performance. These accomplishments represent the first step in integration of the overall system, and will provide real data for the laser and TV preprocessing and scene-analysis programs.

W74-70348 **502-03-51**
Langley Research Center, Langley Station, Va.
ELECTRONIC MATERIALS AND PROCESSES
G. B. Graves 703-827-3745
(502-03-52; 502-03-53)

Research in selected areas of electronic materials and processes will be conducted. Analytical studies and laboratory investigations of materials and processes with potential application in the development of new electronic devices to meet future aerospace mission requirements will be emphasized. Research contracts will be used to further develop these materials and processes for device fabrication. Current efforts on electronic materials include research on organic materials with controllable indices of refraction for application as the storage medium in optical mass memory systems under development by NASA and research on various III - V compounds for application in electro-optical devices. Materials and processing techniques will be investigated for the development of a high resolution, two color, light emitting diode display and an x-y addressed liquid crystal matrix device for application in aircraft and spacecraft display systems.

W74-70349 **502-03-52**
Langley Research Center, Langley Station, Va.
ELECTRONIC DEVICES AND COMPONENTS
G. B. Graves 703-827-3745
(502-03-53; 502-33-51)

Research programs leading to the development of advanced electronic components and devices will be conducted. The objective of this research is to provide increased performance in spacecraft and aircraft electronic component and devices at increased reliability and reduced costs. To meet these objectives, new materials and processes will be applied to advanced device concepts in a unified in-house and contractual program. Feasibility of advanced device concepts will be demonstrated in-house on both a theoretical and experimental basis. Also, research contracts will be used to further develop the process technology and device concepts for application to spacecraft and aircraft electronic systems. Areas of research which are being emphasized currently are: The temperature stabilization of liquid phase epitaxial garnet films for application in an all solid state data recorder; the development of charge coupled devices for buffer memory and filtering applications; and the development of solid state photosensor arrays for planetary imaging and spectrometry.

W74-70350 **502-03-53**
Langley Research Center, Langley Station, Va.
SOLID STATE SENSORS AND PROCESSING TECHNIQUES
G. B. Graves 703-827-3745
(502-03-51; 502-03-52; 502-23-56)

The objective is to develop an advanced solid state sensor and component technology leading to improved devices for aerospace vehicle and earth observation applications. This will be accomplished through research on new solid state materials and processing techniques and the subsequent development and application of these new concepts to prototype devices. Emphasis will be placed on the exploitation of solid state characteristics and processing techniques which provide advantages over existing technology, e.g., size, reliability, sensitivity, efficiency, bandwidth, and high temperature operation. Specific technology areas to be investigated include: metal alloy and semiconductor strain gages with improved gage factor and high temperature characteristics; radiation and ion implantation doped semiconductor infrared detectors techniques and high spatial resolution ion detector for mass spectrometry; ion implantation doping of II-VI and III-V compound semiconductors with improved electro-optical and high temperature properties; and diagnostic techniques for assessing new material properties, processing techniques and prototype device performance.

W74-70351 **502-23-18**
Goddard Space Flight Center, Greenbelt, Md.
GEOPHYSICAL MEASUREMENT TECHNOLOGY
John H. McElroy 301-982-6542
(502-23-15)

This RTOP is to provide the technology necessary for the development of precise space-to-space, space-to-ground ranging systems and techniques for calibrating, through the atmosphere, spaceborne measuring systems. NASA's 1977 flight missions require satellite-to-satellite range accuracy to 2 cm and range, range-rate information to .003 cm/sec. A large portion of the component development being conducted under RTOP 502-23-15 has application to these requirements. The major component developed under this RTOP is for higher power CO2 transmitters (20w), tunable waveguide lasers to compensate for larger Doppler shifts, spaceborne neodymium laser transmitters, and image

converter receiver for the detection of laser pulses (.2 ns to 3 ns pulse width). In FY-74, system analysis will be conducted for a CO2 laser range and range-rate system. An earth beacon experiment will be performed with Skylab to develop calibration techniques for on-board sensors. A preliminary study will be performed to determine the transmission spectra of the atmospheric pollutants and the sensitivities required to develop techniques to monitor the atmospheric pollution through varying zenith angle using spacecraft retroreflectors.

W74-70352 **502-23-41**
Langley Research Center, Langley Station, Va.
EARTH-ORIENTED ATTITUDE REFERENCE
G. B. Graves 703-827-3745
(502-23-44)

The overall objective of this work is to develop technology for simple, low-cost attitude determination systems for sensor pointing, and for navigation of earth-oriented, orbital spacecraft. A prototype model, IR horizon sensor head has been fabricated and is being tested. Laboratory equipment and techniques to calibrate and evaluate the sensor are being developed. A logic module to combine multiple horizon sensor heads into an operational attitude determination system will be designed. Analytical error studies of the four-sensor configuration indicate a local-vertical measurement accuracy of 0.005 to 0.008 deg (1 sigma) is achievable. First performance tests on the prototype sensor head show that it can locate the simulated earth horizon with a repeatability of less than 0.01 deg. (1 sigma). This work will provide technology for a simple attitude determination system for application in pointing and navigation of earth orbital vehicles, including shuttle sortie pallets, shuttle launched research and applications modules, and advanced applications satellites.

W74-70353 **502-23-42**
Marshall Space Flight Center, Huntsville, Ala.
INERTIAL COMPONENTS
B. F. Walls 205-453-0793
(909-51-33; 909-55-10; 909-55-33)

The objective is to produce an operational laser gyro with high accuracy and reliability that can be used in future systems of precise rate and position sensing. The unit can be easily adapted to navigation systems as well as rate and position sensors and position trackers. A second objective is to produce a three-axis strapdown inertial navigation system with performance that exceeds the presently available high quality inertial systems in accuracy and reliability with a considerable reduction in weight, size and cost. In addition to the development, testing, and evaluation of laser gyros and controls, a complete strapdown laser gyro navigation system is being constructed for system evaluation tests in a mobile van and aircraft flight. This system includes: (1) a three-axis laser gyro sensor package and control electronics developed with OAST, FY-72 funds; (2) a three-axis accelerometer package and control electronics developed in-house at MSFC with OSS funds; (3) a small ultra-reliable modular computer (SUMC) developed with OMSF, FY-72 funds; and (4) a software program for strapdown systems developed with OMSF funding which will be implemented into this system. This system test program is a cooperative effort between the Systems, Computer and G and C Divisions of Astrionics Laboratory at MSFC and LaRC using on-going programs funded by OSS, OAST and OMSF.

W74-70354 **502-23-43**
Goddard Space Flight Center, Greenbelt, Md.
ADVANCED COMPONENTS FOR PRECISION CONTROL SYSTEMS
H. E. Evans 301-982-5194
(502-23-44)

This task covers research, design, and evaluation of cost effective advanced control and stabilization components and related control circuitry for precision pointing applications and long duration missions. Components and control systems for both earth orbital and interplanetary applications are included. For precise pointing systems, prototype components and control systems will be developed to extend bandwidth and eliminate hardware limit cycling by using unique designs that minimize pertubating forces due to friction, wear, thermal effects, and transmissibility. The ultimate objective of this work is a cost effective system with a pointing accuracy of 0.01 second of arc and an operating life of 10 years. Component technology advancements include the technical breakthroughs in the areas of electronic commutation and magnetic suspension techniques. These concepts are integrated into cost effective precision component designs such as long life bearings (magnetic, hydrodynamic), isolation systems, and advanced motors and actuators. Speed and position control systems compatible with these new concepts form part of this work. Results of this work directly supports unmanned earth orbital and planetary missions and the manned earth orbital and shuttle programs.

W74-70355 **502-23-44**
Langley Research Center, Langley Station, Va.
ADVANCED SPACECRAFT AND EXPERIMENT CONTROL SYSTEMS
G. B. Graves 703-827-3745
(909-74-08; 909-74-35; 502-23-43; 502-23-46)

Technology will be developed to permit the design of cost-effective spacecraft and experiment control systems for earth orbital missions. Simulations will be made of new and existing control concepts for earth orbital vehicle/missions in order to determine required system and component performance. Effective system configuration, low-cost system integration, multipurpose operation, and component standardization will be used to reduce system and component costs while achieving required performance. Control software and hardware needs will be defined and development efforts undertaken. Critical hardware elements will be carried through laboratory development to establish feasibility. This effort is directly coordinated with GSFC, JSC, MSFC, and JPL. GSFC developed components will be integrated into Langley control actuator hardware.

W74-70356 **502-23-46**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
EXTENDED LIFE ATTITUDE CONTROL SYSTEM (ELACS) FOR UNMANNED PLANETARY VEHICLES
Robert V. Powell 213-354-6586

The long range objective of Extended Life Attitude Control System (ELACS) is to develop and demonstrate a spacecraft control concept that is applicable to a wide range of unmanned, planetary missions, such as outer planet flybys and orbiters, atmosphere probes, landers, sample and return, and comet or asteroid rendezvous. In combination, these missions demand improvements in technology for longer life, improved accuracy, lower weight, less power, and greater cost effectiveness. It is also the goal of ELACS to produce technology advancements that can be utilized by other space programs. The approach depends upon the concept of a programmable processor capable of being programmed to meet the requirements of the different individual missions and vehicles. The processor must be hybrid in order to interface with both analog and digital inputs and outputs. In FY-73 a single thread design was completed for a programmable processor, called HYPACE, and the concept was selected for the MJS'77 mission. The next generation for FY-74 involves the attainment of the orginal goals by incorporating fault tolerance and low cost effectiveness, with high reliability. New technology advances must be made in the other control system hardware to meet the low cost and reliability requirements. Analytical formulations are required for control laws, system integration, and dynamic analysis. Increased autonomy is a necessity due to communication distances. Since absolute reliability is impossible to achieve, failure tolerant designs must be incorporated at all levels. These concepts will be demonstrated at a hardware system level, on a gas bearing spacecraft simulator.

W74-70357 **502-23-31**
Marshall Space Flight Center, Huntsville, Ala.
OPTICAL MASS MEMORY
Earl J. Reinbolt 205-453-3770
(502-03-51)

The long range objective of the RTOP is a random access, read-write memory of 10 to the 12th power bits capacity utilizing holographic techniques for writing on an erasable medium. Power,

speed, size, and weight characteristics are to be compatible with in-flight space use in the late 1970's and into the 1980's. The key elements of a read-write holographic optical memory are a laser(s) beam deflector(s), block data composer, reversible holographic storage medium, and an output detector array. These elements combined with suitable optics, electronics, and mechanical structures can provide a functioning read-write memory. The RTOP approaches the problem on three levels to provide vital information on system feasibility: (1) Overall memory system includes system design to accomplish progressively higher bit capacity, a study of memory architecture and computer interfaces, and a building of limited engineering prototypes if funding permits. (2) Optical memory component and technique development places special emphasis on critical items such as the storage material and block data composer. LaRC 502-03-51, Electronic Materials and Processes, is addressed to the materials problem. (3) An optical memory breadboard containing all of the key elements has been constructed. It is and will continue to be used experimentally to study all component interfaces and allow development of new devices and the enhancement of old devices. The breadboard is to be interfaced with an operational computer to study the computer memory relationship.

W74-70358 **502-23-32**
Goddard Space Flight Center, Greenbelt, Md.
AUTOMATED DATA HANDLING TECHNIQUES AND COMPONENTS
D. H. Schaefer 301-982-5184

Earth Resource spacecraft sense a very large number of images in many spectral regions. It has been estimated that, for operational missions, sensors may be receiving inputs at a total rate equivalent to 10 to the 12th power bits per second. In order to effectively utilize this avalanche of information, data reduction on-board the spacecraft must be performed. The focus of this RTOP is to develop methods of on-board analysis of data generated in Earth Resource and other image sensing missions. Three tasks are being undertaken. The first is the hardware development of parallel image processing systems. Such systems process all points of an image simultaneously. Technologies capable of performing such processing include coherent optical techniques, noncoherent optical techniques, advanced large scale integration techniques, and techniques involving electron optics. The emphasis is to develop automatic image processing systems that can accept an image directly as an input and, in a parallel manner, process this image to obtain desired information. Such systems may well combine several types of parallel image processing techniques into a single piece of hardware. The second task is that of developing methods of using the hardware that comes into existence under the first task. This includes the--

W74-70359 **502-23-33**
Lyndon B. Johnson Space Center, Houston, Tex.
MULTIPROCESSOR FAULT TOLERANT COMPUTER DEVELOPMENT
E. A. Dalke 713-483-4065

This activity continues the development and implementation of a multicomputer fault tolerant processing system capable of performing time critical, safety of flight, in-line operations, and multiprocessor redundant backup configuring. This effort will reinstate some of the initial objectives of the FY-72 multiprocessor RTOP funding which were rescheduled in the interest of early investigation of multicomputer hardware configurations with emphasis on program cost reduction. Subsequent trade studies have demonstrated a continuing need for a multiprocessor configuration capable of automatic redundancy voting and functional reconfiguring in real time. A laboratory system hardware configuration consisting of aerospace computers, an input/output interface unit, a keyboard/display communication system, and peripheral recording/playback mass memory will be integrated with a fault tolerant, multicomputer software executive. Utilizing a data bus communication link to vehicle subsystem, the configuration will investigate levels of redundancy cross-strapping, software/hardware voting requirements, and manual or automatic switching criteria. Through the use of mass memories, the reliability issue of program reloads will be investigated in the light of software modularizing and real time constraints for backup or redundancy.

W74-70360 **502-23-01**
Lewis Research Center, Cleveland, Ohio.
MICROWAVE AMPLIFIER TECHNOLOGY
Robert E. Alexovich 216-433-6689

The objective to advance the state-of-the-art of microwave power amplification for space and terrestrial applications above one GHz. To achieve this objective, research and technology development programs will be undertaken on microwave amplifiers, high current density electron emitters and high power microwave passive components. Studies and investigations of space-earth propagation and interference will be undertaken to guide power communication component and subsystem investigation. Specific techniques such as multi-stage depressed beam collection and beam refocusing for linear and crossed-field amplifiers are among promising techniques being investigated.

W74-70361 **502-23-11**
Goddard Space Flight Center, Greenbelt, Md.
MICROWAVE NEAR EARTH DATA TRANSFER AND TRACKING
V. R. Simas 301-982-4654

The objective of the work under this RTOP is to achieve technological advances in data transfer and tracking systems in order to satisfy the demanding communication requirements for future space flight projects, such as space shuttle, Earth Observation Satellite program, and TDRS. The capability and performance requirements on the communication links for these advanced projects are characterized by high data rates (up to 200 Mb/s) simultaneous multilink operation, and reliable long life operation. The attainment of these parameters requires technological advances in both spacecraft and ground terminal techniques and hardware. High power efficient solid-state amplifiers at Ku-band will be developed. This will circumvent the liabilities associated with vacuum tube TWTs, namely limited life, size and weight, and high voltages. These advances will be utilized in the development of a 200 Mb/s PSK quadriphase modulated spacecraft transmitter package capable of direct communication to ground or to a data relay spacecraft. Room temperature parametric amplifiers for spacecraft receivers at S-band, C-band, and Ku-band having noise temperatures of 150 degrees Kelvin or less will be developed employing hybrid microwave integrated circuits to achieve an advanced degree of miniaturization. All solid state components will be utilized both to enhance size and weight reductions and to significantly improve operational reliability.

W74-70362 **502-23-12**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
MICROWAVE TECHNIQUES AND COMPONENTS
Robert V. Powell 213-354-6586
(502-33-92)

The broad objectives of this RTOP are to develop microwave techniques, components, and subsystem technology required for NASA earth and planetary missions in the 1977-1987 decade. Technology needs of microwave radiometry for earth and planetary sensing, radar for earth and planetary mapping, and communications from earth orbit, terrestrial planets, and outer planets, will be included. NASA microwave technology needs have been surveyed by the SPART study, and will be periodically monitored, to insure responsiveness to the full range of mission requirements. Large microwave antennas are needed for high resolution radiometry, radars, and high data rate communications from the terrestrial and outer planets. The objectives are to develop cost-effective designs utilizing the inherent advantages of conical reflector antennas, and to reduce the cost of designing and testing antenna systems by upgrading and unifying computer analysis capability and developing near-field measurement techniques. This RTOP develops theoretical techniques to increase understanding of the interaction of a radio wave with the environment through which it propagates. This work involves developing techniques for inferring the characteristics of atmospheric turbulence from the radio data as well as techniques for processing the radio data. Microwave radio techniques and components are needed

for all NASA missions. This RTOP will develop advanced radio technology and components that will substantially reduce the cost of S/C microwave communications, navigation, radio science, and sensing systems, while improving performance, capability, reliability and lifetime, and reducing size, weight, volume, and power consumption. This will be accomplished with the use of beam leaded active and passive components bonded to ceramic microstrip substrates; a large reduction of variable, tweeked elements; incorporation of surface wave filters and monolithic multipliers; and by digitizing the low frequency portions of the radios.

W74-70363 **502-23-14**
Goddard Space Flight Center, Greenbelt, Md.
TECHNOLOGY FORECASTING FOR SPACE COMMUNICATIONS
Ford Kalil 301-982-2357

The Networks Directorate interfaces with all space programs and provides recommendations to new programs regarding telecommunications and related systems for the most efficient utilization of existing and projected ground networks capabilities with minimum augmentation. These recommendations must especially consider the spacecraft systems whose implementations could be impractical or more costly than augmenting the ground systems. The Networks Directorate recommendations must consider the overall telecommunications system from the viewpoint of both the spacecraft and the ground. Hence, the purpose of this RTOP is to: (1) provide the Networks Directorate with current and projected state of the art performance for parameters, components, and systems used in space electronics, in particular space telecommunications and integrally related systems; and (2) provide cost-effectiveness evaluations for different component and system configurations based on a broad range of mission profiles. The approach will be to: (1) provide continuous computerized review of technology and techniques used in space electronics with emphasis on telecommunications and related systems, subsystems, and components; and (2) evaluate the present state of the art and provide meaningful technology forecasts in several areas such as power sources, modulators, detectors, data processing components, antennas, and optical apertures, acquisition, and tracking/pointing, prime power (power supplies) weight and thermal factors, lifetime, efficiencies, optimizations, and cost effectiveness of practical configurations related to various actual and projected mission requirements.

W74-70364 **502-23-15**
Goddard Space Flight Center, Greenbelt, Md.
OPTICAL DATA TRANSFER SYSTEMS
Walter J. Carrion 301-982-4942

NASA flight missions of the late seventies will need high capacity data transfer systems. This RTOP is for the development of the technology to provide 400 MBits/sec data transfer terminals for space to space to ground links. The CO2 (10.6 micrometer) heterodyne systems and Nd:YAG (1.06 micrometer) which offer the best promise to meet these requirements are being developed. Theoretical, analytical and trade-off studies are conducted to establish system parameters. R and D to advance the state-of-the-art of critical components is carried out in such areas as waveguide lasers, optical mixers (10.6 micrometer), diode pump-lasers, III-V detectors (1.06 micrometer), modulators, etc. Acquisition and tracking techniques for S/C terminals are being developed and incorporated in the development of brassboard models that are in spacecraft configurations. Systems are evaluated in the laboratory to determine bit error rate and establish the magnitude of the effects imposed by the atmosphere, using an atmospheric channel simulator. Flight experiments to measure the effect of atmospheric turbulance on optical data transfer system is carried out using high altitude balloons (100K ft.). In FY-74 the detail statistics of visible wavelenth fluctuations will be measured to optimize the design of future optical data transfer systems. Tracking control development is carried out to dynamically control the pointing of optical ground based transmitters and receivers. Two specific problem areas require solution in FY-74: high precision (2 arcsecond) autotrack capability, and satellite position prediction improvement to provide prediction accuracies of + or - 'arcseconds for efficient acquisition with very narrow laser beams.

W74-70365 **502-23-47**
Ames Research Center, Moffett Field, Calif.
PRECISE, ALL SKY POINTING, ATTITUDE REFERENCE SYSTEM FOR SHUTTLE EJECTABLE PAYLOADS
John V. Foster 415-965-5083
(879-40-00; 188-78-81)

The objective of this investigation is to develop and evaluate a precise, all sky pointing, attitude reference system. This system will satisfy the attitude reference requirements of a large class of shuttle ejectable payloads, including planned small astronomy payloads. The attitude reference system will use solar and stellar sensors to provide an initial three axis inertial reference. Precise all sky pointing will be provided by strapdown rate integrating gyros and a special digital processing unit. The star sensor, gyros, and digital processing unit will be a modular addition to existing solar pointing type systems such as SPARCS. Recently available tuned rotor gyros will be used to provide inertial grade performance at moderate cost and without the use of power consuming heaters. State-of-the-art digital electronics will be used to enhance the modular approach and will perform gyro signal computations and special static and dynamic gyro calibration. In-house analysis and simulations will be performed leading to concept verification with a system breadboard using the existing SPARCS air bearing facility and a SPARCS attitude control system.

W74-70366 **502-23-51**
Marshall Space Flight Center, Huntsville, Ala.
DESIGN, PROCESSING AND TESTING OF LSI ARRAYS
D. L. Anderson 205-453-3770

The overall objective of this effort is to develop technology and automated techniques for the design, processing, and testing of large scale integrated circuit arrays having predictable, long operating lifetime. This program includes two tasks: (1) the investigation and development of automated techniques for the design, processing, and testing of large scale integrated circuit arrays; and (2) the development and evaluation of new technologies which offer improved performance and reliability for microelectronic devices. Automation of design and testing is well advanced, so the major effort in this area will be in automating wafer processing. New technology development will be directed at improved performance and long life. The work performed under this program will be closely coordinated with, and complement, the work being conducted on predictable long-life microelectronics at the Jet Propulsion Laboratory and Langley Research Center.

W74-70367 **502-23-52**
Marshall Space Flight Center, Huntsville, Ala.
SCREENING AND RELIABILITY TESTING OF MICROCIRCUITS AND ELECTRONIC DEVICES
L. C. Hamiter 205-453-3986

The objectives are to develop approaches for assessing and assuring predictable long operating life of microcircuits and other electronic devices used in aerospace applications. The approach on selected microcircuits will be to eliminate the failure mechanisms caused by loose conducting particles, bad wire bonds, and damaged or improperly dressed lead wires. This is being accomplished primarily by the transition from flying leads to beam leads. The beam lead technology has now been developed and the effort remaining is to assure that the processes can be implemented on a production scale for the various types of microcircuits. An all tantalum capacitor that does not degrade with shelf-life and nominal use stresses is being developed. The capacitor effort also consists of developing more explicit application and derating criteria for tantalum capacitors to improve their long life characteristics. Accelerated testing techniques are being investigated as a method of making more accurate and quicker assessments of long life stability and characteristics of microcircuits. A new task is being initiated to determine if any available solid encapsulated devices can perform reliably in long life applications and, if so, develop techniques for separating the ones that are acceptable from the ones that are not.

W74-70368 **502-23-53**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
PREDICTABLE LONG-LIFE COMPONENT TECHNOLOGY
Robert V. Powell 213-354-6586

The objective is to provide a major segment of the technology necessary to achieve long-lifetime microelectronic devices of predictable life characteristics. Life prediction modeling work will emphasize the effects of individual processes on end-item reliability. Accelerated testing methods for life characteristics are to be developed and verified. Quality assurance activities will center around developing the Automatic Visual Inspection System and identifying new instrument concepts. Instabilities in thermally grown oxides will be the area of emphasis in failure physics. Dielectric film and metallization processing technique aspects which are predictability and control-oriented will be pursued. Technical requirements for dielectric substrates will be developed for both hybrid and monolithic applications. Applications of electron spectroscopy for chemical analysis (ESCA) will be stressed following completion of system tests. Design guidelines for predictable long-life hybrid microcircuits will be developed. The approach of this RTOP is based upon intercenter coordination meetings which defined general priorities and objectives. The selected JPL tasks are based upon nonduplication of effort and an established expertise in both facilities and personnel.

W74-70369 **502-23-54**
Goddard Space Flight Center, Greenbelt, Md.
ASTRONOMICAL SENSORS AND IMAGING SYSTEMS FOR LARGE SPACE TELESCOPES
Lawrence Dunkelman 301-982-4988
(188-45-51; 188-78-57; 188-78-56; 502-33-94)

The purpose of this effort is to develop high performance optical image recording system(s) for advanced astronomical space telescopes. As a corollary effort it is planned to develop holographic reflecting gratings. These gratings are desired because the low scattering properties present information of higher fidelity. In order to realize the observational potential of the Large Space Telescope, current technology must be modified, extended, and improved to provide the full range of detectors required. Emphasis is placed on electro-optical detection techniques in order to provide high quantum detectivity, desired spectral response, and the capability of electronic readout. Other characteristics such as resolution, format, magnification, and image control must be matched to space telescope instrumentation requirements which are being developed simultaneously. These techniques in conjunction with real-time image processing are used to enhance the system performance to increase the design capability of the space telescopes. Also it is planned to develop, through light interference phenomena, spaceflight qualified reflecting diffraction gratings that exhibit optical/mechanical properties which are superior to mechanically ruled diffraction gratings. Spectral information is to be isolated by the development and applications of diffraction gratings produced by holographic techniques. Stigmatic imaging, dispersion and effective---

W74-70370 **502-23-55**
National Aeronautics and Space Administration, Washington, D.C.
ELECTRONIC DEVICE AND SYSTEMS SUPPORT
C. E. Pontious 202-755-2440

The objective of this program is to provide effective coordination of NASA sponsored research and development efforts on electronic devices and systems with similar work supported by DOD and other government agencies. Through associate membership on the Advisory Group on Electron Devices and its constituent Working Groups, NASA program managers receive expert advice on the feasibility, currency and soundness of planned R and D procurement activities, long range R and D requirements, complementary work in other government agencies, and forecasts of new technical developments.

W74-70371 **502-23-56**
Langley Research Center, Langley Station, Va.
HIGH RESOLUTION ENVIRONMENTAL SENSORS
G. B. Graves 703-827-3745

The basic objective is to develop high resolution sensor technology which relates the NASA research programs and requirements in remote and in situ sensing of earth and planetary environments, and the measurement of space shuttle structural characteristics in simulated reentry environments. Technology areas to be investigated are: (1) airborne hydrographic lidar systems for measurement of ocean depth, fertility, and turbidity; (2) continuously tunable infrared diode lasers for high resolution absorption and emission spectroscopy of low concentration atmospheric constituents; (3) lasers and laser systems for use in relating laser scattering, absorption, and fluorescence measurements to particulate and molecular constituent distributions in the atmosphere and bodies of water; (4) diode lasers with visible emission and improved performance for use in spectroscopic instrumentation, optical ranging, and optical data processing systems where small size, coherence, efficiency, and reliability are primary constraints; (5) ultrasonic sensors for particulate detection in turbid fluids; and (6) high temperature strain, heat flux and vibration sensors for space shuttle structural measurements.

W74-70372 **502-23-57**
Goddard Space Flight Center, Greenbelt, Md.
HI REL SEMICONDUCTOR MANUFACTURING INVESTIGATION
J. Lyons 301-982-2204

In order to provide hi rel semiconductors, a manufacturer must include process controls and inspection steps which deviate from his normal manufacturing routine. This requirement is disruptive and expensive because the portion of his work requiring hi rel controls is small compared to the portion destined for the commercial market. This RTOP will investigate the feasibility of buying parts from the commercial manufacturing line and qualifying them to hi rel standards at Goddard.

W74-70373 **502-33-13**
Langley Research Center, Langley Station, Va.
SPACE SHUTTLE: ANTENNA TECHNIQUES AND MATERIALS
G. B. Graves 703-827-3745

Analytical techniques, with experimental verification, will be used to determine optimum antenna locations and the effects of RSI (Reusable Surface Insulation) and antenna window materials on SS Orbiter antenna performance. Ar anna designs supplied by Johnson Space Center will be modeled to analytically determine the effects of Orbiter configuration and RSI coatings on the antenna radiation patterns. New and/or improved RSI materials selected for the Orbiter will be measured to determine their dielectric properties at high temperatures so their effects on antenna performance may be predicted.

W74-70374 **502-33-51**
Langley Research Center, Langley Station, Va.
SOLID STATE DATA STORAGE SYSTEMS
G. B. Graves 703-827-3535
(502-03-52; 502-03-51)

This effort will be directed toward developing a solid state data storage system capable of storing one million to 10 to the 8th power digital data bits using the bubble domain technology. Previous and current research effort (RTOP 502-03-52) on bubble domain materials will be used as a technical base for achieving low defect density, temperature stable materials capable of storing up to 100,000 data bits on a single chip. Using these materials the necessary circuit technology will be developed to obtain a 100,000 integrated storage device. Logic design techniques will be investigated to determine the optimum data formatting and processing techniques for a flexible data storage system with capacities from one million to 10 to the 8th power bits to meet a wide range of spacecraft payload applications. The bubble domain device and logic design efforts will establish the feasibility for further development of data storage systems. A solid state data storage system will be designed, developed and fabricated suitable for flight demonstration in a satellite payload.

W74-70375 **502-33-53**
Marshall Space Flight Center, Huntsville, Ala.

SENSOR AND INSTRUMENTATION RESEARCH
W. T. Escue 205-453-4627
(502-33-86)

The technology being conducted in the areas of acoustic emission, zero g quantity, gas analysis, and propellant utilization/loading sensors is an extension of work being conducted under RTOP 502-33-86. FY-74 technology will continue in respect to development of these tasks for future mission requirements.

W74-70376 **502-33-82**
Flight Research Center, Edwards, Calif.
A VEHICLE STATUS AND MONITORING SYSTEM
W. P. Albrecht 805-258-3311

A state-of-the-art system designed for monitoring and continuous inflight recording of parameters which determine the operational status of a vehicle will be flight tested in a high performance jet aircraft. Operational discrepancies are monitored in-flight and identified when sensed quantitied exceed predetermined thresholds as inserted into the computer. The computer also performs a decision-making operation and identifies the component or fault which most likely caused the problem by means of a tape printer on board. The decision is based upon diagnostic logic information which is stored in the airborne central processor unit. All of this information is available to the ground crew immediately following the landing. The flight experience and data accumulated will provide basic information for system requirements for the space shuttle vehicle to achieve short turnaround time by automatic system testing, fault location, and checkout. An objective is also to demonstrate the ability to refly the engine-inlet system based upon data from the last flight with little or no formal ground preflight of that system.

W74-70377 **502-33-85**
Lyndon B. Johnson Space Center, Houston, Tex.
ZERO G QUANTITY GAUGING SYSTEM
Jack Alexander 713-483-3466

The object of this task is to develop the empirical calibration data to confirm or modify the theoretical propellant simulation program used in the nuclear zero-g quantity gauge. The nuclear gauge depends on predicting the geometry of fluid surfaces for low bond numbers to optimize weight and minimize errors. The test data that has been generated on fluid performance for zero-g conditions contains many assumptions and extrapolations particularly as concerns the slosh rates and settling times of the fluids since true zero-g conditions could not be sustained for a sufficient length of time. The approach will be to instrument a test tank with a nuclear gauge containing enough source/detector pairs to X-ray a known mass so that the geometry of the mass can be reconstructed and the gauge propellant simulation program modified to optimize the weight and accuracy of the nuclear quantity gauge.

W74-70378 **502-33-01**
Lewis Research Center, Cleveland, Ohio.
SPACECRAFT TECHNOLOGY ASSESSMENT
E. H. Davison 216-433-4000
(502-04-01; 502-24-03; 502-25-70)

The objectives of the work described herein are to provide an assessment of the requirements of the users of advanced space technology, to generate conceptual designs of various spacecraft, spacecraft systems, and subsystems, and to evaluate the cost and potential benefit of various proposed experimental programs. Other government agencies, industrial organizations and universities will be contacted to determine their needs and interests in technology areas of concern to the Space Flight Programs Directorate. In-house design studies and analyses will be performed to determine experimental program requirements and systems and subsystems designs necessary to satisfy the user requirements. Studies will also be made of the cost of those experimental programs and of the benefits that might accrue from such programs to serve as a guide in longrange program planning. Emphasis will be placed on experimental programs which have an attractive cost/benifit ratio and which can be implemented for the nominal sums of money judged to be available for new program starts during the next few years.

W74-70379 **502-33-31**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
ADVANCED DIGITAL DATA SYSTEMS FOR DEEP SPACE
Robert V. Powell 213-354-6586

The goal of this work is the development of concepts and technology for integrated spacecraft data systems. The data system of a spacecraft performs the functions of spacecraft control, automatic maintenance, acquisition and processing of engineering and scientific data, data storage, and timing and sequencing. Work is focused on achieving a unified data system approach for NASA missions in the 1980's including those missions which support a semiautonomous roving vehicle. Emphasis is now being placed on data system architecture which will lead to standardized multimission capability at low cost and on data storage technology for imaging systems. Previous techniques developed under this RTOP provide a basis for achieving the desired capability in a unified multimission approach. The work in FY-74 will continue the on-going work with the emphasis toward the standardized low cost multimission data system which was mentioned above. The data gathering requirements of missions will be investigated in order that a standardized measurement processing approach can be developed. The methods necessary for testing the data system will also be considered. Fault-tolerant computer development will continue with work on computers executing higher level languages and in work on a more optimum memory utilization. The work in source encoding will also continue. Previous work on high density storage techniques has led to a storage method which does not use moving parts, and this work will be continued.

W74-70380 **502-33-41**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
GUIDANCE AND NAVIGATION FOR UNMANNED PLANETARY VEHICLES
Robert V. Powell 213-354-6586
(502-23-12; 502-23-46; 502-33-92; 310-10-60; 310-10-61; 310-10-62; 310-10-64; 310-10-69)

The objective of deep space navigation is to deliver the spacecraft to the target in a manner that permits mission objectives to be achieved. Candidate missions in the late 70's-80's may have their objectives seriously compromised by dependence on capability expected from conventional Doppler and range radio tracking. New concepts and measurement data types (e.g. interferometry, multi-frequency, on-board measurements, etc.) can help satisfy the anticipated demands resulting from the complex kinematics and dynamics of the future ballistics and low thrust missions. This RTOP is directed toward the attainment of greater mission potential and probability of success through capabilities available from the new radiometric, target and celestial reference measurement techniques and improved orbit determination and maneuver strategy technology. Developments under this RTOP are required to realize inherent navigation system performance potential from S/C on-board measurement, attitude control and microwave subsystem SRT within OAST and the DSN microwave system SRT within OTDA. Navigation requirements analysis will provide the focus for activities during FY-74. Orbit determination performance prediction software needed to perform measurement optimization/tradeoffs will be developed in conjunction with measurement subsystem analysis and maneuver strategy technology development. The S/C based satellite/star optical measurement technology will be further automated and investigated for use on small body missions. Satellite ephemeris development technology will complement the satellite/star observations in improving approach and orbit phase navigation. The first steps will be taken in the analysis and development of S/C based measurement, orbit determination, maneuver determination and execution command generation for the realization of autonomous on-board navigation capability.

W74-70381 **502-33-92**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
MICROWAVE SYSTEMS TECHNOLOGY
Robert V. Powell 213-354-6586
(502-23-12)

The objectives are to develop radio, radar, and sensing systems to plan and execute NASA's earth and planetary missions in

the 1977-1987 period. These missions have needs extending from over a 35 db increase in link capability for high-rate outer planet flybys down to noncoherent low-rate capability for entry probes. This RTOP develops communication, navigation, and sensing systems to meet mission baselines in performance, life, reliability, and cost; provides viable system alternatives for cost effective early mission planning; and exposes new mission opportunities. The approach in FY-74 is to finish the MVM'73 S/X experiment which demonstrates precision navigation and coded high-rate X-band telemetry. This RTOP provides the system effort for the S/X experiment; radio hardware modifications are provided under RTOP 502-23-12. Coding techniques for noncoherent MFSK channels will be developed for entry and relay missions. A pulsar navigation system study will be undertaken to achieve accurate autonomous or semiautonomous navigation and as an alternate to possibly expensive two-station tracking. A dual access two-station transponder interference tracking scheme to improve accuracy and reduce cost will be analyzed. A digital spacecraft receiver development will start so that advantages of digital components can be applied to NASA radio, radar, and radiometry. Modeling of random rough dielectric scattering with shadowing will be started to improve detection and mapping of radar and radiometry returns in earth and planetary missions. Techniques to enhance expected data return subject to minimum constraints developed to take advantage of non-worst case conditions in new propagation media as in Saturn and Uranus entry will be improved.

W74-70382 **502-33-94**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
ADVANCED IMAGING SYSTEMS TECHNOLOGY
Robert V. Powell 213-354-6586

The long-term objective of this RTOP is the development of imaging system technology to meet the anticipated requirements of future planetary imaging missions. The general approach includes the study of future missions as a source for the postulation of future imaging requirements, the study of current and projected imaging technology as a means of establishing a state-of-the-art baseline, and the implementation of specific technology development tasks to provide the desired enabling technology. Current efforts are concentrated on the development of solid-state imaging sensors for both Mariner and Pioneer-class spacecraft, based upon charge-coupled device (CCD) technology. These devices have the potential advantages of small size, reliability, scan versatility, geometric fidelity, magnetic cleanliness, and very high sensitivity. Furthermore, they may lead to an integral solid-state camera (excluding optics) with major cost savings to future missions.

W74-70383 **502-33-95**
Langley Research Center, Langley Station, Va.
VIDEO GUIDANCE, LANDING AND IMAGING SYSTEM FOR SPACE MISSIONS
Eugene S. Love 703-827-2893.
(186-68-66; 502-33-91)

The objectives of the present study are threefold. The first objective is to investigate in greater depth the problems associated with a video landing site selection system for post-1975 Viking lander missions. It has been statically demonstrated that a video system scanning two-dimensional terrain photographs is capable of selecting a safe or the least hazardous landing site on the photographs (Roger Schappell - Martin Marietta). However, more realistic studies must be conducted with a dynamic system and three-dimensional terrain models in order to properly evaluate the concept. The second objective of the study is to investigate the use of a video system for rendezvous and/or landing on small planetary bodies (asteroids, comets, small moons, etc.) during the terminal guidance phase (less than 10 kilometers). The third objective is to investigate the use of a video system for rendezvous of unmanned earth-orbiting spacecraft during the terminal guidance phase (less than 1 kilometer). All three of the above tasks are somewhat similar in that the video data will be processed on-board the spacecraft and guidance corrections will be performed autonomously. Some of the video images of the target bodies will be of great interest to the scientists and method of obtaining and transmitting these images.

W74-70384 **502-19-31**
Ames Research Center, Moffett Field, Calif.
NUCLEAR FLIGHT RESEARCH AND ANALYSIS
Glen Goodwin 415-965-5065

To appraise the abort-reentry performance of space nuclear power supplies, such as multi-hundred watt radioisotope heat sources and their components. To develop and evaluate improved heat source configurations that will lessen heat source susceptibility to environmental challenges against the heat shield but will be fully compatible with operational requirements. Exploratory testing and analysis will be carried out on existing and proposed space nuclear power supply systems and their components. Breakup modes, aerodynamic stability, heating rate distribution, internal temperature distribution, ablation, thermal stress and thermal velocity will be determined for various abort entry trajectories. In cooperation with the LASL experts on fuel and its compatibility with materials, design and develop integrated fuel protection and containment modules suitable for assembly into large RTG heat sources.

W74-70385 **502-19-34**
Langley Research Center, Langley Station, Va.
RECOVERY AIDS FOR AEROSPACE NUCLEAR SYSTEMS
G. B. Graves 703-827-3745

This RTOP covers the technology development for underwater sound generators and detection devices that will permit accurate location of nuclear electrical power systems in salt water. One of the critical requirements of the sensor is that it be integrated into an RTG system design and remain in close proximity to the radioisotope fuel cell. It must, therefore, perform normally after long periods of exposure to high temperature (400-600 C). Unique power sources such as the direct application of chemical energy, salt water activated batteries, and solid state batteries will be investigated. Candidate location aid designs will be carefully assessed to assure reliable operation after vehicle reentry and free-fall water impact.

W74-70386 **502-10-01**
Ames Research Center, Moffett Field, Calif.
QUANTUM ELECTRONICS
Glen Goodwin 415-965-5065

The objectives are to conduct experiments and analysis of topics in the physics of quantum electronics that relate to the development of lasers; to applications in solar physics, space physics, and atmospheric physics; and to applications in space flight technology. In addition, to develop new laser devices that will operate at greater efficiency than present devices; that will operate at shorter wavelengths in the optical, u.v., and even the X-ray region of the spectrum; and that will have potential high power capability for transmitting radiation energy long distances through space. An arc jet will be used to energize a cw. laser of medium power (about 10 kw) which can handle a variety of gas mixtures, a variety of test section configurations, and a variety of optical cavities to investigate different concepts of laser optimization and new lasing media for shorter wavelength operations. A 24-inch low-density shock tube is being converted to a hybrid electric-discharge gasdynamic laser device to investigate the potential efficiency advantage of this approach. The 60 joule, 30 nanosec Nd glass laser is being modified so that it will optionally produce 15 Gw peak power in a 3 nanosec 45 joule pulse so that it will have extended range for studies of laser-matter interaction and the search for potential X-ray lasers.

W74-70387 **502-10-01**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
QUANTUM ELECTRONICS
John W. Lucas 213-354-4530

The first objective is to conduct the research required to develop various types of high power efficient short wavelength lasers. Emphasis is placed on the understanding of the basic physical phenomena governing the interaction of radiation and plasma kinetic processes that determine the efficiency, operating wavelength, size, and power output of laser devices. The second objective is to investigate experimental phenomena associated with propulation inversion in nuclear Zeeman levels and to study the feasibility of using the phenomena for a radio/microwave

frequency maser. The third objective is to attempt to induce lasing in superfluid helium at vacuum UV frequencies, use superfluid helium excited by electron bombardment to efficiently excite lasing states of atoms and molecules dissolved in the helium, and to develop a theory of mirrorless distributed feedback lasers. The fourth objective is to use ion cyclotron resonance spectroscopy (IRC) to measure product distributions and reaction rates for charge transfer reactions which selectively produce electronically excited product ions. Ion-molecule reactions which may selectively depopulate lower state populations are being examined. This fundamental knowledge is being applied on the construction of a prototype flowing afterglow ion laser, which has the potential for high power output in the ultraviolet and visible wavelength regions. The fifth objective is to measure cross sections for electron-molecule (atom) collision processes that are important in plasma and laser devices. The methods of electron impact spectroscopy are utilized to study optically forbidden transitions and metastable productions.

W74-70388 **502-10-01**
Langley Research Center, Langley Station, Va.
QUANTUM ELECTRONICS
Eugene S. Love 703-827-2893

A plasma focus device will be used to investigate the emission spectra of a fissioning uranium plasma in the UV range (below 2000 Angstroms), since the non-thermal contribution from the fissioning plasma is assumed to be significant in this range. A knowledge of non-equilibrium radiation from a fissioning plasma is important if it is to be used as a source for laser pumping or other radiation. The plasma temperature and density will be determined by optical methods such as the slope of the bremsstrahlung, ionization stage, and line profile. Studies of the formation of the dense plasma focus and potential application of the device will be continued. The extremely hot (50 to 80 million degrees K) and dense (10 to the nineteenth particles per cubic centimeter) plasma produces very high neutron fluxes of the order of 10 to the seventeenth neutrons per second per square centimeter. Various parameters of the plasma focus will be changed to investigate scaling laws, using neutron yield as the performance indicator. To gain additional information on the focus formation, the studies of neutron and X-ray emissions will be continued. In addition, the possibilities of neutron radiography and fast activation methods will be investigated. The interaction of intense CO2 laser radiation with the dense plasma focus will be investigated, specifically the efficient conversion of laser radiation to X-rays. The resulting intense X-ray flux is of interest to materials structure studies and as a source for possible X-ray laser pumping.

W74-70389 **502-10-02**
Lewis Research Center, Cleveland, Ohio.
RESEARCH IN MAGNETICS AND CRYOPHYSICS
James C. Laurence 216-433-4000

The primary objective of the Lewis program is to achieve intense magnetic fields in large volume with a minimum mass and power requirement. Basic and applied research to improve the current density, operating temperature, and strength of superconducting materials are required. A second objective is a better understanding of the physical processes involved in conduction of electricity both in the normal and the superconducting state, to improve the performance of aerospace power and propulsion systems. Superconductors will be studied theoretically and experimentally on both physics and engineering levels. In normal metals and semiconductors, the galvanomagnetic effects will be studied, especially in high fields where Landau quantization is important. The intent in each area will be to understand and to develop materials and processes with unique characteristics for specific applications. Superconductors (wire, ribbon, composites, etc.) will be tested in short samples and in actual coils to ascertain relative merits of different materials and construction techniques. Improved superconducting composites will be sought in order to improve superconducting magnets. LeRC high field superconducting and cryogenic magnets, and cryogenic facilities will be used in experiments directed towards new and better materials. Studies to minimize weight and power requirements for superconductive magnet systems will be made.

W74-70390 **502-10-03**
Lewis Research Center, Cleveland, Ohio.
PLASMADYNAMICS
G. R. Seikel 216-433-4000

The objective is to gain the ability to generate, confine, and manipulate plasma of desirable characteristics in ways relevant to potential advanced power and propusion applications of importance to NASA. Investigations are aimed at both under standing the physics of the processes and demonstrating the feasibility of high performance systems. Investigations will also attempt to define possible new system concepts that could lead to new NASA applications and missions. Analytical and experimental studies which include extensive diagnostics will be made. Topics to be investigated include: MHD generators for both open and closed cycle electric power systems, high temperature plasma heating and containment in open and closed magnetic geometries, and the collisionless interaction of a high velocity plasma stream with magnetic fields. Investigations will include studies to define potential system performance, critical technology needs, and alternative applications of technology developed.

W74-70391 **790-93-08**
Langley Research Center, Langley Station, Va.
ANALYSIS, ADVANCED CONCEPTS, PLANNING AND SYSTEMS SYNTHESIS
Eugene S. Love 703-827-2893

The objectives are to provide technical support to the OAST Space Technology Program in the areas of future planning, quick response analytical support to Headquarters program management, and intuitive and speculative thinking for the future in space; to develop and apply new optimization theories to network routing problems; and to assess socio-economic modeling, technical forecasting, etc., and determine their potential value to NASA programs and planning. The approaches to achieving their objectives are: (1) to develop long-range mission models, to assign personnel responsibilities for special analytical tasks in space exploration and operations to support OAST requests, and to assign a spokesman for speculative thinking at LaRC who will interact with other Center spokesmen; and (2) to continue the development and to apply a new optimization technique originated at the LaRC to optimize routes (ranging from bus to airline to space communications) by minimizing the cost of operation. The theory of System Dynamics as applied to Urban and World Dynamics will be developed further to study the effects of technological advances on such problems as pollution control, and to determine other possible areas of application such as technological forecasting, technology assessment, and policy analysis.

W74-70392 **790-93-09**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
ADVANCED CONCEPTS AND FUTURE PLANNING
Robert V. Powell 213-354-6586

The objective is to provide a small but identifiable base for the discussion, generation, and coordination of intuitive and speculative thinking in regard to the future of man's involvement in space. Building the capability for conceptualization in conjunction with the search for new knowledge incorporated in the basic research activities of NASA and other government agencies, the universities, and industry will lead to sounder, more relevant and more timely proposals for space activity. This objective will be implemented by lectures and seminars, coordinated research and technology interfaces with external activities in this field, communication with similar activities in the other NASA installations and by small groups or panels with expertise in the field in consulation with NASA management. The lead in this activity will be taken by the Advanced Concepts and Missions Division with participation by Langley, Lewis and JPL.

W74-70393 **790-93-10**
Lewis Research Center, Cleveland, Ohio.
ADVANCED SERT SPACECRAFT TECHNOLOGY
E. H. Davison 216-433-4000

The objectives of the work described herein are to define advanced SERT missions and spacecraft configurations, to determine costs and development schedules for mission/

spacecraft programs, to assess the application of these programs to the requirements of advanced space technology users of solar electric power and propulsion, to determine the SRT required to support these programs, and to conduct critically required SRT. Other government agencies, industrial organizations and universities will be contacted to determine their needs and interests in technology areas indicated above. In-house design studies and analyses will be performed to determine flight test program requirements and systems and subsystems designs necessary to satisfy the user requirements. Studies will also be made of the cost of those experimental programs and of the benefits that might accrue from such programs to serve as a guide in long-range program planning. Emphasis will be placed on experimental programs which have an attractive cost/benefit ratio and which can be implemented for the nominal sums of money judged to be available for new program starts during the next few years. The nature and extent of the SRT required for the selected program will be established and the SRT effort initiated.

W74-70394 **790-93-41**
Ames Research Center, Moffett Field, Calif.
SPACE EXPLORATION - MISSION AND SYSTEMS ANALYSIS
B. L. Swenson 415-965-5890

The objective is to define the mission and spacecraft requirements to accomplish recognized scientific goals of exploration within the solar system. These studies will be aimed at determining mission strategies and the associated vehicle requirements to accomplish these goals with minimum cost and maximum scientific benefit. In this regard, examinations will be made of the benefits and cost of the use of advanced and evolving technologies, subsystems, and vehicles.

W74-70395 **790-93-42**
Langley Research Center, Langley Station, Va.
SPACE MISSION AND VEHICLE ANALYSIS
Eugene S. Love 703-827-2893

The purpose is to provide studies of future space missions and new systems concepts to assist in developing the basis from which decisions can be made on future space missions, mission models, and systems. These include preliminary studies of future space missions and techniques; feasibility studies of missions proposed as a result of preliminary studies; atmospheric and in-space trajectory analyses associated with proposed future missions; studies of guidance and navigation requirements relative to such missions; studies of the use of trajectory determinations methods in defining planetary masses and gravity fields; and ephemerides improvement and error definition required for mission studies. The needs for several future missions are under study. These include multiple comet/asteroid flybys, and planetary landers and rovers. The types of orbits, types of propulsion systems, types of spacecraft measurements and instrumentation, and modes of operation are being studied. Current activities include development of long range programs for the scientific exploration of the solar system through mission studies, analyses of Jupiter and Saturn satellite lander missions and Mars rover missions, asteroid ephemerides improvement, and development of parameter estimation and mission design techniques for mission planning purposes.

W74-70396 **790-93-44**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
MISSION AND VEHICLE ANALYSIS
Robert V. Powell 213-354-6586

One task of this RTOP is to develop cost estimating models for the support of pre-project planning activities of unmanned planetary exploration missions. The cost models are based on NASA, JPL, and industry data. The first step of this process consists of the development of science instrument cost estimating models and ultimately would be expanded to generate estimates of project cost based upon mission objectives and other mission level parameters. A second task is to identify novel NASA missions made possible by space instrument and device cryogenic cooling below 15 deg K using helium. there is a considerable effort at JPL sponsored both by OSS and OA to develop cooling for spacecraft instruments at liquid helium temperatures. More general and far-ranging benefits for detectors and electronic devices will be proposed and investigated to determine the feasibility of selected missions making maximal use of these benefits. A third task is proposed to investigate, analyze, and seek solutions to the problems of optimizing end-to-end video data links used in planetary exploration by establishing fidelity criteria. Finally, the explosive propulsion activity described in the FY-73 RTOP will be completed.

W74-70397 **790-93-45**
Ames Research Center, Moffett Field, Calif.
SPACE UTILIZATION - MISSION AND SYSTEMS ANALYSIS
J. M. Deerwester 415-965-5897

The objective is to conduct and support studies to determine the potential applications of space. These applications are such that they meet current and anticipated future needs on earth and that contribute to future space exploration missions. Applications so identified, and the attendant technology requirements, can respectively serve to aid in setting directions for Agency planning and for the OAST technology development programs. Candidate missions and systems will be evaluated with respect to fulfillment of needs; economic considerations; and technology implications. This RTOP applies primarily to the utilization of missions and systems operating in space. In some cases, however, analysis of space missions must include the consideration of similar applications performed by more traditional means. Means by which the techniques of systems analysis can be brought to bear in fulfilling the needs of the user community will also be addressed within this RTOP.

Space Systems and Experimental Programs

W74-70398 **755-42-01**
Langley Research Center, Langley Station, Va.
METEOROID TECHNOLOGY SATELLITE
Eugene S. Love 703-827-2893

The Meteoroid Technology Satellite (MTS) is a Scout launched near-earth experiment to obtain baseline data on the effectiveness of bumpers or multiwall structures and the velocity distributions of meteoroids. Measurement will also be made of the flux of very small meteoroids. The velocity measurement is a joint Langley Research Center/Johnson Spacecraft Center experiment.

W74-70399 **755-44-01**
Lewis Research Center, Cleveland, Ohio.
SPACE PLASMA HIGH VOLTAGE INTERACTION EXPERIMENTS (SPHINX)
R. R. Lovell 216-433-4000

The objective of the Sphinx Project is to obtain engineering data that is necessary to design high voltage systems that can be exposed directly to the space environment, and to obtain flight data that will serve as a reference set for further ground testing. In addition to the main experiment there are three auxiliary solar array experiments that will be integrated into the Sphinx satellite. An experimental system capable of investigating the coupling of high voltage surfaces with the space plasma will be developed and integrated into a self contained satellite. This satellite will be launched into an elliptical orbit by the Centaur launch vehicle as part of the Titan/Centaur Proof Flight in January of 1974. The experimental surfaces will be raised to for + or - 16 kilovolts by means of a high voltage power supply. The degree of coupling with the space plasma will be determined by measuring the current in the bias circuit. The measurements will be made over a period of a year as a function of altitude and as a function of time at high voltage.

W74-70400 **756-48-01**
Flight Research Center, Edwards, Calif.
ENTRY TECHNOLOGY CONFIGURATION FLIGHT EXPERIMENT
Jack L. Kolf 805-258-3311

The subsonic and low supersonic characteristics of a configuration representing an advanced class of entry vehicles is being studied by means of a coordinated flight and wind-tunnel test program with the X-24B. The program will yield the detailed aerodynamic characteristics of a high hypersonic L/D entry vehicle and an indication of the ability of the wind tunnels to predict these characteristics. A flight test approach will assess the handling qualities and piloting problems of this class of vehicle while determining performance and stability and control characteristics. Energy management and approach schemes will also be investigated during unpowered flight periods.

W74-70401 **757-54-01**
Goddard Space Flight Center, Greenbelt, Md.
MAGNETIC TAPE RECORDERS
John M. Hayes 301-982-2779
(160-20-52; 757-54-05)

Magnetic tape recorders have been and will continue to be the primary means of data storage in spacecraft. The purposes of this plan are to increase the reliability and decrease the cost of recorders primarily through the development of standard recorders. Herein, two standard recorders are described along with the component and system developments needed for their implementation. Analysis and testing of bearings and lubricants are typical of the component areas that must be pursued, to be able to predict the performance of spacecraft recorders. Other component areas to be pursued include brushless dc motors. By means of this plan these standard designs will be created and verified. Following this verification, procurements will be effected to provide sources of recorders for most of the NASA programs.

W74-70402 **757-54-02**
Goddard Space Flight Center, Greenbelt, Md.
STANDARD SPACECRAFT COMMUNICATIONS AND DATA MANAGEMENT
Ronald M. Muller 301-982-4043
(757-54-06)

The objective is the development of low cost, reliable, standardized flight equipments for spacecraft communications and data management. Designers of missions in the late 70's and beyond will be able to form nearly optimal systems using these equipments as building blocks. Parameters such as bit rates, number and type of data and command channels, receiver bandwidths and transmitter power output will be selectable over wide ranges by using a flexible and modular approach. Cost will be lower than present cost for such systems because: (1) Nonrecurring cost will be minimal for each new system. (2) Large volume usage will be possible (modules used across all projects). (3) Standardized ground checkout of both equipment and procedures will be possible. (4) More use of modern electronics such as large scale integration (LSI) will be possible because even though the initial investment will be higher, it will be more than made up by production labor economies. (5) Actual reliability (rather than calculated reliability) of flight equipment will become well known. Tailoring the amount of redundancy needed to satisfactorily complete a mission will then be possible. (6) Ground operations, both before and after launch, will cost less because all people involved will be familiar with the performance of the flight hardware. (7) Prime spacecraft contractors need spend manpower on only those items that are unique to his mission requirements.

W74-70403 **757-54-03**
Goddard Space Flight Center, Greenbelt, Md.
DEVELOPMENT OF MODULAR SPACECRAFT DATA SYSTEMS
Donald C. Lokerson 301-982-5378

Each scientific spacecraft requires a PCM telemetry data system consisting of at least: clock, multiplexer, A/D converter, encoder and format generator, sub commutator, and sync pulse generator. No matter how varied mission requirements are, a data system would include these elements developed to a level of complexity necessary to meet a particular mission's needs. Experience with small spacecraft has established a relative lower limit of complexity for a data system for a functional spacecraft with a single scientific experiment and necessary supporting housekeeping parameters. In contrast, experience with large observatory spacecraft has indicated data systems requirements for a large number of experiments with many commandable functions, variable bit rate flexible formatting, memory storage, and on-board computer control. The objective of this RTOP is to develop a modular telemetry data system which can be expanded to meet the requirements of a large range of missions, such as IUE, SATS, IME, and others.

W74-70404 **757-54-05**
Goddard Space Flight Center, Greenbelt, Md.
LOW COST STABILIZATION AND CONTROL SYSTEMS
Henry C. Hoffman, Jr. 301-982-4496

The objective is to provide a low cost stabilization and control system that will satisfy the requirements of all unmanned earth orbiting spacecraft beginning in the mid to late 1970's. The system will comprise a set of interchangeable building blocks, based upon currently qualified components, that can be assembled into a specific mission control system without additional development or qualification. GSFC now has an active program to provide a set of universal components for all of the Center's in-house satellites, beginning with the IUE and SATS and extending to Nimbus-G, Tiros-N and other GSFC projects. Under this RTOP the program will be extended to all umanned earth orbiters both current and future. The first key to success is to provide true interchangeability not only with other stabilization and control components but also with other subsystems. To this end, a major emphasis will be dedicated to the systems engineering between stabilization and control and the power, communications, data handling, thermal and other subsystems. The second key to success is provision of maximum flexibility consistent with low cost. To identify those parameters that can and should be variables, cost analyses will be made to establish the cost penalties for each variable. Hardware development will be initiated early in the program for the dual purposes of providing useful flight component designs and of setting up laboratory systems to evaluate the performance and compatability of the system components. The laboratory systems will not be restricted to stabilization and control hardware but will include all of the hardware being produced through complementary RTOP's for other subsystems.

W74-70405 **757-54-06**
Goddard Space Flight Center, Greenbelt, Md.
STANDARD HEAT PIPES FOR THERMAL CONTROL
Stanford Ollendorf 301-982-5228
(502-21-27)

The objective is to standardize the techniques used to manufacture heat pipes in order to reduce their cost. The approach which is considered is: (1) to formulate standard procedures and processes for fabricating and testing heat pipes; and (2) to apply these standard procedures and processes to proven designs, in order to develop a complement of reliable heat pipes for spacecraft temperature control.

W74-70406 **757-54-08**
Goddard Space Flight Center, Greenbelt, Md.
DEFINE STANDARD SPACECRAFT INTERFACES
M. I. Schneebaum 301-982-2101

The standard spacecraft system as it presently exists consists of a number of housekeeping-type subsystems which can be standardized to achieve large cost savings in future flight programs. In addition, a driving force in many future programs is the requirement for proper spacecraft and spacecraft subsystem interfaces with sensors which are mission-unique. Standardizing the spacecraft subsystems themselves will allow a much firmer general interface definition with these one-of-a-kind sensors. As a corollary, the problem of early sensor development will be alleviated greatly by utilizing the results of this standardization of interfaces to make the sensors as developed easily compatible with spacecraft which have not been defined at that point in time. The approach of standardizing the functional format of the several interfaces involved is the method which will yield the greatest results in the absence of available standard spacecraft hardware at this time.

W74-70407 **757-54-09**
Goddard Space Flight Center, Greenbelt, Md.
LOW COST THERMAL CONTROL SYSTEMS
Edward I. Powers 301-982-5115
(502-21-27)

The objectives are to develop standardized thermal design methodology for spacecraft payloads, and to develop standardized thermal control systems with the objective of significantly lower cost than that currently experienced by use of unique designs. The approach which is considered is: (1) to examine the current methods of thermal design including both active systems such as louvers, heat pipes, and heaters, and passive techniques such as insulation coatings with the objective of defining costs to achieve optimal designs consistent with reliability and operational requirements; (2) to review manufacturing and testing methods for producing such hardware as louvers, heat pipes, coatings, heater/thermostat units with the goal of eliminating extraneous/unnecessary activities; and (3) to review current computer programs and methodology used in thermal analysis in order to standardize on those which offer the greatest savings in engineering and machine time.

W74-70408 **757-54-10**
Goddard Space Flight Center, Greenbelt, Md.
MODULAR SYSTEMS APPROACH TO LOW COST SHUTTLE SUPPORTED PERMANENT SPACE PLATFORMS
R. R. Drummond 301-982-6731

Modular spacecraft approaches aimed at creating capabilities for on-orbit repair, refurbishment, or reconfiguration become primary drivers in configuring spacecraft systems for space shuttle supported operations. These capabilities have broad economic significance in the shuttle era in terms of revolutionizing spacecraft and programmatic concepts. Modular permanent space platforms (PSP) acting as multimission carriers that can be assembled and modified in space have been extrapolated from systems concepts aimed at providing module exchange capability. Assembly in space lifts all launch vehicle constraints on spacecraft configurations. This permits a new look at versatility in terms of purely functional modular arrangements, realistic standardization, and truly low cost designs for long term operations. An exosystems modular platform concept has been developed as a practical approach to module exchange accessability, as well as for optimum utilization of shuttle transportation system capabilities. The exosystems approach offers little systems constraints, thus subsystems, old or new, can be interfaced and packaged for use on the PSP, based on individual functional characteristics only. No unique systems technology is required specifically for the PSP concept, with the exception of interfacing components, bus type distribution networks, and modular packaging. The technical feasibility of the PSP concept, and its impact on both NASA programming and attainment of low cost shuttle supported operations modes, are the basic thrusts of this RTOP.

W74-70409 **757-54-22**
Lewis Research Center, Cleveland, Ohio.
STANDARDIZED LOW COST SPACE POWER SYSTEMS
H. Schwartz 216-433-6910

In order to substantially reduce the cost of electric power systems used on future missions, a Standardized Low-Cost Power Systems Office will be established. This office, acting under guidance provided by a high-level Headquarters and inter-center steering committee, will manage a coordinated program to design, build and qualify for use an inventory of low cost standardized power system elements. Initial efforts will be devoted to standardizing solar cell specifications and developing a standard module; updating nickel-cadmium battery specifications, and defining and qualifying a line of standard cell sizes; assembling a list of current power processing hardware; developing a handbook of preferred circuit design practices; defining a standard power processing system, and qualifying a group of regulator-conditioners; and designing a series of solar array extension and orientation systems for future spacecraft.

W74-70410 **757-54-41**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
STANDARDIZATION OF ELEMENTS OF ELECTRICAL POWER SUBSYSTEMS FOR UNMANNED SPACECRAFT
Robert G. Forney 213-354-6709

The object of this RTOP is to reduce the cost of electrical power subsystems for NASA spacecraft through an organized and integrated effort to standardize the design, fabrication and test of the major elements of this subsystem. Through standardization, many non-recurring and recurring electrical power cost factors will be significantly reduced or totally eliminated. A list of specific objectives to be covered by this plan include: (1) standardization of spacecraft power system design, (2) standardization of power processing equipment for multiple mission applications, (3) standardization of solar cell modules and solar array power sources for multiplemission applications, (4) standardization of the battery selection criteria, (5) standardization of RTG power source test and evaluation and (6) standardization of low cost RTG power source for multiple mission applications. This effort would be conducted in concert with other NASA space flight centers to insure that the product produced is applicable to the majority of future NASA missions and that the projected cost benefit could in fact be realized. Benefits will be realized through this program by reduced development and documentation cost, reduced design test and qualification repetition, and reduced risk of new development.

W74-70411 **757-54-42**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
LOW COST CONTROL SYSTEM SENSOR STANDARDIZATION
Robert G. Forney 213-354-6709

The long range objectives of this program are to make available standardized, low-cost attitude control optical and inertial sensors which will meet a broad range of mission requirements within the NASA space program. The near-term objectives are to assess all the needs of the NASA community for attitude control optical and inertial sensors and to define the broadest functional and performance requirements that can be met with low cost standardized sensors. Over a three year period this program will result in the selection and qualification of attitude control sensors that are applicable to the majority of NASA spacecraft. These spacecraft applications will be selected on the basis of their potential for use of standardized sensors and will include such missions as are represented in the JPL Block Planetary mission set. This standardization will result in significant cost savings which will be realized through increased sizes of procurement lots, reduced documentation, reduced numbers of spares, reduced development risk, and reduced quality control effort. The program will involve the cooperative effort of all NASA space flight centers to insure that the standardized items are in fact used and that the projected cost savings will be realized.

W74-70412 **757-54-43**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
LOW COST, COLD GAS ATTITUDE CONTROL PROPULSION STANDARDIZATION
Robert G. Forney 213-354-6709

The Attitude Control Propulsion (ACP) Working Panel, under NASA's Space Cost Evaluation Project, has shown that most planned, unmanned, orbital and planetary spacecraft have requirements for ACP which can be met by two types of ACP systems if options are allowed in thrust and total impulse. As the Panel recommended, it is hereby proposed to develop a low cost, standardized cold gas ACP system at the subassembly level with options in tank and thruster sizes. The second system type utilizing hydrazine is covered in a related RTOP. An estimated net cost savings in excess of $1.0 million will accrue to NASA on each flight program (i.e., two flight spacecraft) if this plan is followed. Flight projects will draw initial standardized components in 1975 and the entire family of subassemblies will be qualified and available in early 1977. Because the technology is fairly mature, technology advances per se will not be required. The FY-74 efforts will concentrate on the detailed definition of requirements and specifications for the subassemblies and components, culminating in the preparation of requests for proposal for contracts to develop and test the low cost, standardized hardware. The program will involve the cooperative effort of all NASA space flight centers to insure that standardized

items are in-fact used and the projected cost savings will be realized.

W74-70413 **757-54-44**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
LOW COST N2H4 ATTITUDE CONTROL PROPULSION STANDARDIZATION
Robert G. Forney 213-354-6709

The Attitude Control Propulsion (ACP) Working Panel, under NASA's Space Cost Evaluation Project, has shown that most planned unmanned, orbital and planetary spacecraft have requirements for ACP which can be met by two types of systems if appropriate options are provided for thrust levels and total impulse capability. As the Panel recommended, it is hereby planned to develop a low cost, standardized hydrazine ACP system at the subassembly level with options in tank and thruster sizes. An estimated net cost savings in excess of $20 million will accrue to NASA during the balance of the 1970's if this plan is followed. Flight projects can acquire selected standardized components in 1975 and the entire family of subassemblies will be qualified and available early in 1977. Because the technology is fairly mature, technology advances per se will not be required. The FY-74 efforts under this RTOP will concentrate on the detailed definition of requirements and specifications for the subassemblies and components, culminating in the preparation of a request for proposal for the development and test of the low cost, standardization hardware.

W74-70414 **757-54-46**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
LOW COST STANDARDIZED PLANETARY SPACECRAFT TRANSPONDERS
Robert G. Forney

Current planetary spacecraft transponder hardware is very expensive and inadequate to meet life and reliability requirements of long life missions. During the past three years, supporting R/D development work totalling $1,600,000 under RTOPs 125-21-09/18, 115-21-09, 186-68-53, 502-23-12, and 502-33-92 has been expended by JPL in developing a low cost, multimission, miniature transponder. This RTOP proposes to perform the final development, fabrication, and qualification of this standardized hardware, capitalizing on the R/D work already performed or being completed in FY-74. Large cost savings are anticipated through amortization of the non-recurring costs over a number of units (block build), as well as the volume procurement of a design which emphasizes low cost producibility. The scope of this RTOP is: to determine the S/X transponder requirements of the planetary spacecraft programs for the 1979-83 period; to complete the development and documentation required for standardization of the transponder; to qualify and life test prototype hardware; to procure flight components in economical 'block' buys; and to provide hardware, documentation, and technical support to the users at appropriate times throughout their programs. The standard transponder will fulfill both the S-band and S/X-band applications. The design utilizes very few variable parts; low power, multi-function integrated circuits in stable, broadband stages; and bandwidth controlled by stable filters. Recurring per unit costs are estimated to be 65 to 75% of similar Viking units.

W74-70415 **757-54-47**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
TAPE RECORDER FOR PLANETARY STANDARDS
Robert G. Forney 213-354-6709

The goal of this effort is to develop spacecraft tape recorders to serve as standards for planetary missions. Emphasis will be on a reliable, flexible tape recorder with capacity of at least 10 to the ninth power bits which will satisfy the vast majority of identified future planetary missions. The previously developed V075-MJS77 tape transport will be the basis of this effort. The approach will be to refine and modularize the transport and electronics to enhance their ability to match a wide range of project requirements and to be compatible with the Mariner Block missions. Design modifications required to achieve this compatibility will be small. An analytical math model of the standard recorder will be generated to obtain detailed understanding of how hardware changes impact performance and in turn to guide the hardware modification. Simultaneously, limited development will be carried out on recording techniques of improved efficiency to achieve the modest increase in desired capacity. The recorder will be developed with a qualified prototype completed at the end of FY-76 and with flight recorders available in early FY-77 and as needed thereafter. In conjunction with this tape recorder effort, work will be initiated in FY-74 on the basic building block for a 10 to the sixth power bit no-moving-part memory using CMOS technology. This device will be applied to store compressed imaging data and low rate cruise data, and when used in conjunction with the tape recorder, can increase the recorder's life, flexibility and range of applications.

W74-70416 **757-54-49**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
FLIGHT OPERATIONS COST IMPROVEMENTS - LONG TERM MISSIONS
Robert G. Forney 213-354-6709

The purpose of the proposed study is to improve JPL competence in an area of known future needs, namely the ability to support long duration missions in a cost effective manner. The study will also supplement the Post-Viking Data System Design Project by identifying in detail the special features required for data system functions required by missions of long duration. This study will select recommended approaches to system design after examining alternatives. Current studies indicate unacceptably high costs for flight operations of missions to the outer planets and automated, standardized approaches to cost improvement must be identified. It is proposed to undertake eight complementary subtasks presented below in order of priority. Each subtask is further described on the continuation page. The subtasks include: (1) effective personnel utilization, (2) automation of project permanent data records (3) standardization of project Mission Support Areas (MSA) (4) accessible spacecraft histories, (5) automatic networking to remote sites, (6) alarm strategy and techniques, (7) automated command and (8) automated spacecraft analysis.---

W74-70417 **757-54-51**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
STANDARDIZATION OF LUNAR AND PLANETARY SUBSYSTEMS
J. D. Burke 213-354-6363
(112-30-20)

The objective is to investigate the opportunities for cost saving through commonality of flight and ground subsystems in a lunar and planetary program extending into the shuttle era. Starting with information generated in prior studies, which concentrated on pre-shuttle planetary missions, a team of experienced people will conduct studies to evaluate (1) technical suitability of common subsystems and operations over sets of lunar and planetary missions to be defined by the sponsor, (2) effect on cost of different degrees of standardization, and (3) effect on cost of different implementation modes. Based on these evaluations the team will then investigate the opportunities for achieving commonality in the advanced development of future subsystems, to provide data helpful in guiding Advanced Systems Technology efforts.

W74-70418 **757-54-52**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
STANDARDIZED G AND C SUBSYSTEM INTEGRATION EQUIPMENT
Robert G. Forney 213-354-6709

The objective is to identify areas of commonality between the G and C integration or support equipment hardware required for various space flight projects throughout the NASA community. The program described by the Mariner Block Proposal exemplifies programs which would benefit from this concept. A further objective is to define equipment sets that have utility over the identified ranges of requirement commonality. The principle FY-74 activities will include identification and delineation of the techniques and equipments currently employed in G and C integration activities. The effort in FY-75 will be devoted to the development of a prototype equipment set with broad program

application potential. During the TOPS Program at JPL, programmable equipment, meeting many of the anticipated requirements, was investigated, and development was started but terminated prior to completion. This experience places JPL in a strong position to conduct this effort.

W74-70419 **757-54-53**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
STANDARD ELECTRONIC EQUIPMENT PACKAGING SYSTEM
Robert G. Forney 213-354-6709

The objective of this RTOP is to develop and qualify a standard spacecraft electronic equipment packaging system having broad applicability to future NASA planetary and interplanetary projects. Use of a new packaging structure design, fabricated from low cost sheet metal and/or extruded parts, will reduce both cost and weight. Additional cost savings will be achievable through larger volume buys of standard items and through reduced requirements for qualification testing. The development will also include a system/subsystem interconnect that features fewer series connections and fewer connectors, and that provides for the potential use of lower cost commercial joining techniques such as wire wrap and/or crimp. The standard spacecraft electronic equipment packaging system will preserve the inherent modularity of the present Mariner system and will permit use of residual Mariner hardware and designs, such that it can be implemented incrementally. To be of maximum benefit to NASA, it will be deisgned to have broad applicability. For example, preliminary studies indicate that it could readily be designed to be applicable to Pioneer. This is an in-house task, but will require liaison with other NASA Centers, to establish commonality of requirements and to negotiate design standards. Certain of the basic technical concepts to be used in the standard spacecraft electronic equipment packaging system were conceived of and partially developed in FY-72 and FY-73 under RTOP 186-70-51. This RTOP will develop and qualify a standard packaging system based on these concepts.

W74-70420 **757-54-54**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
STANDARDIZED THERMAL MANAGEMENT FOR UNMANNED SPACECRAFT
Robert G. Forney 213-354-6709

Standardization of spacecraft subsystems and components is being investigated as an effective means of reducing future mission costs. The thermal management subsystem is also a good candidate for standardization because from JPL experience with interplanetary spacecraft, it has been necessary to tailor and exhaustively test a new design for each mission. A standardized thermal management subsystem should lower the cost of each mission by reducing manpower, hardware fabrication and thermal test requirements. The longer range objective of this task is to develop such a standardized thermal management subsystem for unmanned spacecraft. In FY-74 the effort would be a systematic study of the key thermal problem areas for planetary spacecraft and the standardization options which could solve these problems, using state-of-the-art techniques. The result of the FY-74 effort would be a standardization design methodology that would be implemented in a second phase starting in FY-75. The effort would include the effects of modularization of other subsystems and spacecraft standardization on the thermal management subsystem. Thus other disciplines such as structures, packaging and configuration as well as other subsystems will have a part in the study. A FY-75 start on implementation of a standardization design would be contingent upon an evaluation of the cost effectiveness of the design concepts developed.

W74-70421 **757-54-55**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
UNIVERSAL SCANNING DEVICES
Robert G. Forney 213-354-6709

A great many spacecraft science instruments and telecommunications antennas require motion in one or more degrees of freedom. Three basic types are in common use but in the past each has been designed specifically for a given task. Since it seems probable that these requirements will increase as missions become longer and more complex, standardization is indicated. The task of this RTOP is to design, fabricate and test a family of standard scan devices based upon existing components which could be used 'off-the-shelf' for various missions. Application to shuttle payloads as well as spacecraft missions promise considerable savings in cost.

W74-70422 **757-54-56**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
PLANETARY S/C HIGH-GAIN ANTENNA STANDARDIZATION
Robert G. Forney 213-354-6709

The objective of this RTOP is to design and demonstrate, through the prototype stage, spacecraft high-gain antennas which will serve as a standard units for all deep space missions for the late 1970's and 1980's. Further, this RTOP proposes to investigate the cost-effectiveness of building high-gain antennas for future missions on modular basis, i.e., constructed with standardized parts (reflector, feed, feed support, mounting structure) for flexibility and variety in use. As the result of a recent development (OAST funded) of a high-efficiency X-band line feed, the conical reflector fed with a line source appears to be the most cost-effective candidate for the standard antenna. Therefore, at the onset of the program, a survey of the requirements of the most probable missions during the late 1970's and 1980's and a trade-off between the conical design and other existing high-gain antenna designs will be made. If the conical design verifies the expected cost-effectiveness, a family of S/X band line feeds will be designed, using the OAST technology. Two sizes of the conical-reflector-line-feed antenna, in the range of 1.5 meters to 3.7 meters in diameter, will be fabricated and flight qualified for demonstration. The design information will then be documented for block-buy for future missions. In addition, standard actuators and S/X band high-power rotary joints will also be designed, fabricated, flight qualified, and documented for use with the standard antenna. Concurrent with the trade-off of the antenna design, the concept of building high-gain antennas using modular technique will be investigated. If this technique proves to be cost-effective, the two standard units of the conical antenna will be fabricated on modular basis.

W74-70423 **757-54-59**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
TAPE RECORDER STANDARDS COMPONENT DEVELOPMENT
Robert G. Forney 213-354-6709

The objective is to accomplish limited component selection and evaluation necessary to support development of a family of spacecraft standard recorders. This RTOP, in conjunction with a related RTOP, constitutes a complete plan to develop standard tape recorders through design qualification. There will be four basic members of this family based on storage capacities of 10 to the 8th power, 10 to the 9th power, 10 to the 10th power, and 10 to the 11th power bits. There will be two class of activities in this effort. The first, directed toward supporting development of the 10 to the 8th power and 10 to the 9th power bit standards, will deal with components and will be on bearing and lurbricant selection and on constant force springs. The second will be a definition study on the high capacity recorders and will include work to improve recording efficiency on the tape and work on reel torque-motors and fundamental tensioning techniques.

W74-70424 **757-54-60**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
NONRIGID BODY DYNAMICS AND CONTROL INTERACTION SIMULATION MODULE
Robert G. Forney 213-354-6709
(502-23-46)

Throughout NASA and industry there is a proliferation of software techniques being used and developed for the analysis and simulation of the interaction of control systems with nonrigid vehicles. Significant cost savings could be realized by the development of a Nonrigid Body Dynamics and Control Interaction Simulation Module for the simulation and analysis of attitude

control systems for a general class of vehicles that can be used for a variety of future NASA flight projects. The purpose of this program would be to make the most cost effective utilization of existing software, to avoid duplication of effort, and to initiate efforts to significantly reduce the cost of testing for design verification. An excellent example for application would be the Mariner Block Proposal, where this plan would apply to all proposed configurations, as well as others that may be considered. The costly duplication of software can be seen at every level from general comprehensive programs to small, special purpose programs. Further, the worth of the programs can be called into question due to the lack of adequate test data. Therefore, a cost effective unified approach is proposed. Three principal products will be sought: (1) a general software program for comprehensive system simulation and design verification, (2) special programs for cost effective application to special problems, and (3) the acquisition of flight data that can be used to validate mathematical simulations. A unified approach will be utilized to provide the most cost effective response to software utilization for the simulation of control system/nonrigid vehicle interaction.

W74-70425 **757-54-62**
Lyndon B. Johnson Space Center, Houston, Tex.
SPACE COMMUNICATIONS AND TRACKING - LOW COST RADAR
J. G. Sheppard 713-483-6301

This RTOP provides for a low cost, low power, low weight passive-target radar for use in the 1980's. During the 1980's, many different types of vehicles and missions (shuttle, station, sortie lab, detached payloads, etc.) will be flown. There is a need for short range tracking for area surveillance, collision warning, and rendezvous. This RTOP will provide a radar with parameters economical enough to be used on a variety of missions, yet which will not require any preparation or active cooperation on the part of its targets. This will obviate many of the present needs for target reflectors or transponders.

W74-70426 **757-54-64**
Lyndon B. Johnson Space Center, Houston, Tex.
AEROSPACE COST ESTIMATING AND SYNTHESIS TECHNIQUE IMPROVEMENT
Humboldt C. Mandell, Jr. 713-483-2741
(909-44-35; 975-50-01)

This operating plan encompasses a series of tasks to be performed to improve NASA/JSC advanced manned spacecraft cost estimating and cost synthesis techniques and analysis personnel. The objectives of these tasks are to increase the accuracy and utility of techniques employed to make cost and schedule estimates and perform size and performance related cost trade studies for advanced space programs. Accuracy will be increased through improvement of basic estimating tools (e.g., cost size scaling relationships will be studied in depth). Utility will be increased by creating and employing broader data bases and more generalized estimating relationships, and by developing user-oriented documentation. The approach to increasing accuracy of estimating techniques will concentrate in two areas: the derivation of statistical inferences from nonaerospace and aerospace programs to test hypotheses presently employed in such areas as weight and size cost scaling, learning rates, development and production complexity factors, and inflation prediction; and the analysis and use of recently-acquired data to update presently used cost, weight, and time estimating relationships.

W74-70427 **757-54-71**
Ames Research Center, Moffett Field, Calif.
SYNTHESIS STUDY OF SPACECRAFT SYSTEMS FOR LOW COST PLANETARY SPACECRAFT
John V. Foster 415-965-5083

The objective is to establish standard spacecraft systems, based largely on existing designs, applicable to several different planetary missions. The approach will be to establish a representative set of planetary missions likely to be conducted over the next decade. This mission set will be derived largely from the one published by the Planetary Programs Office, Code SL. Several current subsystem designs will then be analyzed to determine compatibility with the requirements of the mission set. The studies will establish cases where existing component (e.g., black boxes) designs are adequate, cases where modifications would suffice, and cases where new designs are essential.

W74-70428 **757-54-82**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
LOW COST STANDARDIZED PLANETARY SPACECRAFT RF POWER SUPPLIES
Robert G. Forney 213-354-6709

The objective is to produce a considerable reduction in the cost of obtaining spacecraft power amplifiers for planetary programs in the 1979 through 1983 period. This will be accomplished by standardization on a very few multimission designs. In addition to the large cost benefit of standardization and block procurements, the hardware selection criteria will stress high reliability improvements required for long life planetary missions and weight, volume, and power drain reductions required for Pioneer Probe and Comet Encke missions. The scope of this work is: to determine the requirements of the centers conducting planetary missions (Ames/Langley/JPL); to determine the types of standard amplifiers that will economically satisfy most user's needs; to fulfill these needs with existing designs or slight modifications to existing designs whenever this route is most economical; and to design, develop, qualify a prototype, and document the standard amplifiers requiring new designs. The latter approach will make maximum usage of recently-developed or maturing technology.

W74-70429 **757-54-83**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
STANDARDIZED PYROTECHNICS FOR PLANETARY AND APPLICATIONS MISSIONS
Robert G. Forney 213-354-6709
(502-24-46; 180-24-51)

The objective is to achieve advances in pyrotechnics subsystem technology that would allow the use of a family of standardized electrical firing units and standardized hot bridgewire electroexplosive devices in the post MJS'77 planetary missions. This activity will focus on the standardization of modularized capacitor discharge firing units, and on a family of hot bridgewire initiators and electroexplosive devices. Both the firing unit and the electroexplosive devices will be developed with a multimission capability and flexibility. It is intended that the resulting designs would be suitable for all expected worst case environments (i.e., radiation, high temperature, pyrotechnic shock) as well as being capable of functional output modularization. An optimized electronic circuit will be generated using present Viking/MJS technology as a baseline. The circuitry and components will be modularized by one or more packaging techniques to meet a general broad range of expected functional requirements for future missions. Breadboard fabrication and testing will demonstrate the feasibility and utility of such a design and the activity will be concluded with design qualification. The standardized family of electroexplosive devices will be developed from present hardware configuration in that the initiators will be of the hot bridgewire type. It is planned to achieve a device design that is capable of either single bridge or dual bridge application, is capable of long (i.e., 15 year) life, is environmentally resistant and is nonproprietary in all aspects. The promechanical devices will be designed for several---

W74-70430 **757-54-84**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
SOLID ROCKET STANDARDIZED HANDLING AND INSPECTIONS
Robert G. Forney 213-354-6709
(180-32-52)

The primary objective is to provide standard low cost methods, techniques, and hardware, capable of increasing solid rocket motor functional flight reliability by: (1) providing a standard, low cost, rocket motor ground environmental monitoring system to insure motor design limits are not exceeded prior to launch; and (2) providing improved standardized nondestructive test (NDT) techniques to verify acceptable motor quality prior to flight motor installation. Recent reliability studies of upper stage and apogee

motor applications have revealed that motor mishandling and improper ground exposure environments may have contributed to suspected in-flight rocket motor failures. The ability to critically verify motor quality via NDT inspections immediately upon completion of fabrication and just prior to motor flight installation continues to be an area of uncertainty. Standardized methods and procedures for monitoring solid rocket ground exposure as well as improved standardized techniques for performing critical NDT inspections will assure that only high quality solid motors will be accepted for flight installation thus reducing the potential for in-flight failures. These handling and inspection improvements can, and will, be applied to the bulk of all future solid rockets used to support NASA flight projects, including manned shuttle missions, unmanned earth orbital missions, and unmanned planetary missions.

W74-70431 **757-54-86**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
STANDARDIZED SPACE IMAGING SYSTEM
Robert G. Forney 213-354-6709

The objective is to develop a standard space imaging system which can be flown on a variety of missions and spacecraft with minimum cost. Standard electronic and mechanical configurations can be achieved through modification of existing Mariner camera designs to provide a self-contained modular system. Through use of a standard system, substantial cost reductions can be achieved by taking advantage of common hardware procurements and avoidance of new design and development costs for each mission. Candidate future missions where this program may be useful include Viking '79 and the Mariner Block Missions, which consist of JS '77, VO '78, JU '79, LO '80, and JO '81. To achieve standardization for multimission camera applications, there are three technical areas which need to be defined: (1) a standard data interface between the camera and other spacecraft subsystems to minimize cost and complexity of interfacing a camera where data rates may be different for various mission applications; (2) define a standard support equipment (SE) configuration in conjunction with the interface data scheme to minimize programmatic SE development costs; and (3) a flexible, light-weight packaging approach for mission-independent hardware which consolidates the bus and scan platform electronics into a simple modularized unit.

W74-70432 **757-54-87**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
NATIONAL STANDARDIZATION OF LUNAR AND PLANETARY PRECISION TRAJECTORY PROGRAM
Robert G. Forney 213-354-6709

The primary objective is to realize a savings in software development costs for precision trajectory software throughout NASA's space program. A precedent was set some time ago when each of several NASA agencies adopted DPTRAJ through COSMIC, and laid claim to a savings of several millions in software development costs. Similar savings can be realized by other users initially and a year to year savings can be realized by all through updated development modifications commensurate with JPL's present flight technology support programs. A side benefit would be the commonality among all in the use of physical constants and ephemeris data. Standardization would be accomplished by expanding upon the earlier COSMIC venture in a six step program paralleling JPL's on-going flight technology development programs.

W74-70433 **757-54-91**
Goddard Space Flight Center, Greenbelt, Md.
MECHANISMS TECHNOLOGY DEVELOPMENT FOR RESUPPLIABLE MODULAR SHUTTLE SUPPORTED SPACECRAFT
Frank J. Cepollina 301-982-6044

During the GSFC studies of low cost unmanned payloads, particularly the Earth Observatory Satellite (EOS), a concept for satellite on-orbit refurbishment which is compatible with the space shuttle has been evolved. This concept involves a modularly designed satellite and a set of shuttle mounted support equipment which support the launch/refurbish/retrieval operations. The objective is the definition of the interfacing mechanisms which are required to implement the concept of on-orbit refurbishment of a modularly constructed spacecraft. Specifically, emphasis will be placed on the development and fabrication of engineering model latch/release mechanisms, electrical connectors and associated mate/demate mechanisms, which interface subsystem modules and instrument assemblies to the payload system structure. Emphasis shall also be placed on capture and docking mechanisms necessary to dock a modular payload system to the shuttles.

W74-70434 **757-54-92**
Goddard Space Flight Center, Greenbelt, Md.
SINGLE AXIS STRAPDOWN INERTIAL REFERENCE UNIT
Phillip A. Newman 301-982-4421

The objective is to study the commonality aspects of gyro packages so that a single inertial reference unit can be used in various configurations to service all future spacecraft, both prior to and on the shuttle. Since the requirements for the IUE spacecraft are presently well defined it is proposed that its IRU design be used as a starting point. All the IRU requirements, functions, and interfaces will be studied in some detail for future missions. The IUE package will then be designed so that it will be adaptable to a maximum number of future missions without additional development costs. Possible physical configurations will be traded off with cost effectiveness as a major consideration.

W74-70435 **759-11-12**
Langley Research Center, Langley Station, Va.
LASER ATMOSPHERIC TRANSMISSION RESEARCH
Eugene S. Love 703-827-2893
(502-04-36)

The objective of this research is to apply continuously tunable diode laser monochromators (TDLM) to performing high resolution spectroscopic studies of atmospheric abosrption by major atmospheric constituents in the wavelength range of high power infrared lasers (i.e., HF = approximately 2.8 microns, DF = approximately 3.5 microns, CO2 = approximately 10.6 microns). The TDLM has 5 to 6 orders higher resolution than existing high resolution infrared spectrometers and makes it possible to probe for new atmospheric windows. This is of special importance for propagation studies with the new and promising CO(= approximately 5 microns) and HF (= approximately 2.7 microns) lasers whose wavelength ranges lie in the edges of the 6.3 microns and 2.9 microns water vapor absorption bands and need high resolution definition of absorption windows. Research will be continued on high resolution computer models for horizontal and vertical transmission through these absorption windows in the wavelength ranges of CO and HF lasers. The new experimental high resolution information from the TDLM will be used to improve the computer models. High-power pulsed T laser operation will be extended from operation with CO2 to CO, HF, and DF for study of atmospheric absorption and molecular relaxation effects for laser propagation. Experimental and theoretical studies will be performed to extend the wavelengths of chemical lasers to the near infrared portion of the spectrum in order to enhance atmospheric transmissivity and reduce laser beam divergence. This is to be achieved maintaining the demonstrated high efficiency and specific power of chemical lasers radiating further in the infrared, such as HF/DF.

W74-70436 **759-11-21**
Ames Research Center, Moffett Field, Calif.
POWER CONVERSION OF COHERENT LIGHT
Glen Goodwin 415-965-5065

The transmission of high power for long distances through space by laser radiation has been established as a current NASA objective. This will require a converter of laser radiation to useful work at the receiving end. The objective of this RTOP is to develop devices which will convert coherent radiant energy to useful work, electrical or otherwise, with reasonable efficiency, the order of 10% or more. Four possible approaches have been identified: (1) use quantum tunneling at a contact junction diode to rectify the electromagnetic field of the laser radiation; (2) devise a photon engine to absorb pulses of laser radiation in a gas in phase with cyclical expansion and compression such that work is abstracted; (3) develop photocells that have the proper

band gap and voltage-current characteristics to efficiently produce electric power from laser radiation; and (4) use a greenhouse (filter) effect to trap laser radiation in a receiver which has low emissivity for all other wavelengths. The receiver may then operate at high temperature and run a heat engine with reasonable carnot efficiency.

W74-70437 **759-11-24**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
LASER ENERGY CONVERSION RESEARCH
John W. Lucas 213-354-4530

Work will be carried out to demonstrate the feasibility of efficiently coverting laser energy to electrical energy. Investigations include: (1) solid-state devices such as GaAs Schottky barrier photovoltaic converter, and (2) a cesium plasma device such as a laser plasmadynamic (LPD) converter. For the laser photovoltaic energy converter, the emphasis in laser generation development is on the shorter visible wavelenghts (except for the 10.6 micron CO2 laser) and semiconductor materials. Barrier formation techniques compatible with such wavelengths must be examined. The materials to be used will be gallium arsenide and ternary III-V compounds. The barrier fabrication will be the Schottky barrier technique (thin metal film-semiconductor) because of its demonstrated high response at short wavelengths, efficiencies of greater than 40%, ease of fabrication (low cost), radiation resistance, and compatibility with semiconductor thin films. For the LPD converter, experimental parametric evaluation of the existing device will form the basis for an evaluation of its potential. The ion generating LPD converter possesses capability of handling a large power flux (100-1000 w/sq cm) and of achieving the desired efficiency with the proper electrode properties. The critical parameters are the ion generation efficiency and the output voltage. The ion generation efficiency can be unity by making a perfect coupling between the laser and the cesium vapor, and the output voltage can be made sufficiently large if a cesium electrode is used in conjunction with refractory metals having high work function.

W74-70438 **759-11-34**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
LASER DEVICE RESEARCH
John W. Lucas 213-354-4530

The first objective is to develop the necessary technology required to construct various types of high power, efficient, short wavelength lasers. Emphasis is placed on the development of scaling laws that govern the efficiency, size, and power output of specific laser devices. A second objective is to develop inverse lasers operating at short wavelengths which will be able to convert high intensity laser energy from short wavelength lasers into electrical energy for use aboard a spacecraft.

W74-70439 **759-11-43**
Lewis Research Center, Cleveland, Ohio.
HIGHER-POWER LASER SYSTEMS TECHNOLOGY
D. L. Nored 216-433-6948
(502-04-25; 502-02-01; 501-21-33)

This program will define and investigate high-power laser systems and their potential use. Both space and ground-based systems for potential NASA, commercial, and/or military applications will be included. A broad technology base will be provided, as necessary, for realistic appraisal of systems and applications, and for future design, development, and use of such systems. Efforts will concentrate on evaluation and technology investigations of flowing gas laser devices suitable for future high-power laser transmitter systems, efficient power generation systems for such devices, conversion systems for high-power laser energy receivers, optical components unique to large high-power, and on screening and definition of applications. The program approach includes: (1) identification of potential applications and in-depth evaluation of their requirements (a continuing effort); (2) performance of components and system studies (synthesis, definition, design, tradeoffs, and problem-area identification); (3) experimental investigation of component and subsystem technology needed within critical areas; (4) design and operation of high-power lasers to assist in the component technology investigation program; (5) design, fabrication and ground testing of large high-power laser transmitter systems for demonstration purposes, for evaluation of system-type problems, and for applications; and (6) design, fabrication, and operation of systems and experiments applicable to potential applications.

W74-70440 **770-14-02**
Lewis Research Center, Cleveland, Ohio.
AEROSPACE SAFETY DATA BANK
George Mandel 216-433-6285
(502-28-04)

The objectives are: (1) to establish an Aerospace Safety Data Bank to gather, analyze, evaluate, retrieve and disseminate safety-related technical information available to all elements of NASA, its contractors and the technical community; and (2) to assure that information on the latest state-of-the-art regarding safety is available for use in planning, design, fabrication, testing and operations of aerospace vehicles and systems, and associated ground facilities. ASRDI will use the resources and services of the Lewis Computer Services Division for access to the data bases. ASRDI will call on all elements of NASA, its contractors, and other organizations to provide basic, applied, and operational data related to ground-based and flight safety experience for the Aerospace Safety Data Bank. Cooperative and exchange programs have been established with similar information activities in government and industry with the intent of utilizing existing compilations of accurate data. Liaison is being established with these activities to assure access to the information contained in these sources as needed. The information will be analyzed, verified, correlated, and qualified as required. This information will be made available to all elements of NASA, its contractors, other government agencies and the technical community. Improved methods of storing, searching, retrieving, and dissemination information are being developed and implemented.

W74-70441 **770-18-01**
Lewis Research Center, Cleveland, Ohio.
ENVIRONMENTAL ENGINEERING AND ENERGY MANAGEMENT
L. I. Shure 216-433-6341

The nation faces a critical need to meet the increasing demand for energy while at the same time reducing deleterious emissions, exploring new approaches to conserve our natural resources to the maximum, and reducing our dependence on foreign energy imports. The problems are how to measure, quantify, and identify major pollution sources to guide technology efforts and assess benefits; to conserve energy by increasing power conversion efficiency and use of waste heat; and to utilize the systems, both mobile and stationary, more effectively. The objective of this program is to apply NASA space and aeronautics technology, skills, and expertise already developed to ameliorating these problems. The approach is to focus on areas of established and recognized LeRC capabilities primarily related to power and propulsion. These capabilities will be selectively applied to: (1) automotive power technology, (2) stationary power generation, (3) transportation system technology (other than auto), (4) pollution measurement, and (5) generic technology concerning these areas. These will be implemented where needs are clear and the potential from our activities can have substantial impact and benefits. These activities will be undertaken in cooperation with other NASA centers where special areas of expertise apply and with other agencies, local and federal, where these activities impinge on their areas of primary responsibility.

W74-70442 **770-18-02**
Ames Research Center, Moffett Field, Calif.
AIR POLLUTION REDUCTION
Glen Goodwin 415-965-5065
(160-44-79; 501-04-02)

The objective is to assist in validation of a Lawrence Livermore Laboratory developed smog formation and dispersal model of the atmospheric pollution in the San Francisco Bay region. The model will aid in regional planning, in locating fixed monitoring stations, and in calling air pollution alerts. The overall program is a two-year cooperative study between the Ames Research Center, the Lawrence Livermore Laboratory, and the Bay Area Air Pollution Control District (San Francisco) funded by the

National Science Foundation. This RTOP provides laboratory support to this study not available through the NSF grant. The Lawrence Radiation Laboratory has recently demonstrated the feasibility of developing a computer model to predict quantitatively the atmospheric transport of photochemical smog and other pollutants. The Ames Research Center, with an active program for making airborne and laboratory measurements of air pollutants, will obtain atmospheric data at altitudes up to and including inversion layers to verify the prediction of the present model or successors, and to define the magnitudes of the physical and chemical constants needed as input for the model.

W74-70443 **770-18-04**
Langley Research Center, Langley Station, Va.
TECHNOLOGY APPLICATIONS TO ENVIRONMENTAL PROBLEMS
Eugene S. Love 703-827-2893

The objective is to apply Langley technical capability utilizing advanced aerospace technology to the solution of selected environmental problems, such as air and water pollution, and water and waste management. Problem areas for consideration are those identified by one or more user agency, such as EPA, Corps of Engineers, HEW, as well as State governmental organizations, as being of significant value to warrant new technologies. Projects for or in cooperation with individual user agencies where near-term demonstrations can be achieved are most desirable. Proposals to other agencies are also coordinated as a part of this work. Included here are tasks related to the applications of laser radar (lidar) to air pollution sensing, to domestic water and waste treatment, and to systems for applications in the marine environment. In each activity demonstrations will be conducted in close cooperation with users so that comparisons with other existing techniques can be made and so that the relevance of the new technology can be evaluated by the ultimate users.

W74-70444 **770-18-08**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
CIVIL APPLICATIONS - PUBLIC SAFETY/SERVICE AND ENVIRONMENTAL ENGINEERING
D. Schneiderman 213-354-3398

The objective of this RTOP is to apply space-derived capabilities to the resolution of problems of national interest, particularly those relating to the civil systems area, including *public safety/service, medical engineering, environmental* management and others. Such capabilities include experience and technology that is applicable in: project and systems management; systems analysis and project engineering; specialized technical disciplines (e.g., communications, guidance, propulsion, etc.); and design, operation, and evaluation of complex test programs. Within the civil systems area, JPL will complete currently authorized tasks, identify and define problems, determine requirements, apply a systems approach, and concentrate on evaluating feasible hardware pilot demonstrations that will help interested government agencies and/or industrial companies in solving problems that are national in scope. A mix of tasks will be performed appropriate to JPL's capability and emphasizing the application of space technology.

W74-70445 **770-18-10**
Flight Research Center, Edwards, Calif.
APPLICATIONS TECHNOLOGY - ENERGY MANAGEMENT
E. J. Saltzman 805-258-3311

Flight Research Center technology and expertise will be used to investigate means of reducing the aerodynamic drag of box-shaped ground vehicles such as trucks and recreation vehicles, which have very high drag and thus are a factor with regard to our nation's energy management problems. Rectangular vehicles have high drag coefficients. This has been known for a long time but now several factors are converging which make their high drag very important at this time. There are several configuration changes which can substantially reduce aerodynamic drag without compromising volumetric efficiency to a significant degree. Baseline data for the drag of a real vehicle having a sharp cornered box shape will be obtained for interstate highway speed conditions (and lower). Then the same chassis will be used to carry the same volume in follow-on tests for modified geometry. The results of this task will be applicable to truck, trailer, and recreation vehicle design. This work will complement the LeRC effort to define system concepts for a minimum energy automobile.

W74-70446 **770-18-15**
Goddard Space Flight Center, Greenbelt, Md.
LONG RANGE LASER TRAVERSING SYSTEM
L. O. Caudill 301-982-4820

This RTOP is for development of a lightweight, backpacked prototype laser system and for performing field evaluation experiments to determine the feasibility of establishing precise line of sight using the scattered laser light from a distant vertically pointed laser. This work is a direct application of Optical Technology, developed under OAST program, and will provide the United States Forest Service with a surveying technique that will save a great deal of time and money.

OFFICE OF APPLICATIONS

Weather and Climate SR&T

W74-70447 **175-11-41**
Goddard Inst. for Space Studies, New York.
RESEARCH ON NUMERICAL MODELING OF THE GLOBAL ATMOSPHERE AND THE WORLD OCEANS
M. Halem 212-866-3619
(160-44-52)

Research will be carried out on numerical modeling of the world oceans for use in GISS long-range forecast studies with coupled ocean-atmosphere dynamics. Satellite data will be used to verify long-range predictions, and to check climatology of atmosphere and hydrosphere. Work will proceed in two steps. First, the model development will couple a simple ocean model to the advanced multilevel GISS model. Second, improvements in the ocean modeling will be made to include salinity, bottom ocean topography, and ice configurations. The intent is to develop a more realistic model for data assimilation and forecasting studies. Since the ocean surface provides the temperature boundaries for the atmospheric model, the ocean dynamics and accompanying changes in ocean surface temperature are required as an input to all forecasting studies beyond 5 to 7 days.

W74-70448 **175-11-41**
Goddard Space Flight Center, Greenbelt, Md.
RADIATIVE TRANSFER MODELS RELATING TO ATMOSPHERE AND SURFACE CHARACTERISTICS
R. Fraser 301-982-4235

The objective is to determine the radiative characteristics of gaseous and particulate constituents of the atmosphere and of natural surfaces. The proposed work supports the Meteorology Program Objectives of Pollution (M4), Long Term Forecasting (M5), and Processes and Interactions (M6). The radiative characteristics of gases will be obtained from laboratory measurements, theory, high-altitude balloon observations, and satellite observations. Cloud radiative parameters will be derived from aircraft and balloon measurements. Radiative transfer models of clouds will be constructed. The feasibility of utilizing satellite polarization to measure particulate properties will be determined with computer-modeling studies. Models of the scattering characteristics of oceans will be developed. Atmospheric models will be improved for the inversion of the ultraviolet measurements to obtain ozone profiles. During the previous year the absorption line parameters for the 9.6 micrometer ozone band and for the 4.3 micrometer carbon dioxide band were derived from laboratory transmission measurements. Studies commenced on utilizing numerical correlation analyses of the Nimbus 4 IRIS data to detect methane and nitrous oxide in the 1300 wave number band. Work continued on developing an interferometer for a high-altitude balloon flight and the gondola for it was delivered.

W74-70449 **175-21-11**
Ames Research Center, Moffett Field, Calif.

NUMERICAL MODEL AND SIMULATION OF COUPLED EARTH ENERGY AND POLLUTION TRANSPORT CYCLES
Glen Goodwin 415-965-5065
(160-44-51; 160-44-52; 160-44-53; 160-44-54)

The primary goal of this work will be to determine the utility of airborne and satellite observations to mesoscale meteorological prediction, and to demonstrate that utility by incorporating data from such observations in predictive numerical models. These models will be coupled with photochemical dispersion models of air pollution on meso- and regional-scales to demonstrate specifically the economical utility of space technology measurements to air pollution control authorities. A second goal will be to utilize remote platform data in land use analysis in connection with source-inventories for the dispersion models. Available and potential airborne and satellite data will be evaluated with a model currently under development for airport pollution studies which involves numerical prediction of wind fields and thermal stability profiles. Useful kinds of aircraft-obtained data will be collected at two specific modeling sites to demonstrate feasibility and cost of acquiring such data and for use in field verification of the models. Available satellite data will be incorporated whenever possible, and definitions of additional useful measurements will be provided to satellite program offices. The resulting meteorological model will be used to drive dispersion models for prediction of air pollution levels at the two test sites. High resolution photography will also be evaluated as to land use and traffic measurements in regard to source inventory modeling.

W74-70450 **175-21-31**
Langley Research Center, Langley Station, Va.
NUMERICAL SIMULATION MODELS FOR APPLICATION TO ATMOSPHERIC POLLUTION TRANSPORT AND SEVERE STORMS
Eugene S. Love 703-827-2893

This work is aimed at the development of a set of mathematical simulation models which can be applied either individually or in a coupled fashion to problems involving the earth's atmosphere. Problems currently under consideration are pollution transport within the lower atmosphere on scales ranging from regional (5000 km) to urban (100 km). Effects of atmospheric chemistry and topography will be included in urban scale models while regional and mesoscale models will account for gross effects such as radiation and the hydrological cycle. The development of these models will provide a much needed analytical capability which will provide support and an interpretive capability for satellite systems gathering environmental data such as Nimbus G and the proposed Global Environmental Modeling Satellite (GEMS). Models will be used in experiment definition studies to determine the extent of satellite area coverage required, frequency of measurements, nature of data required, and to determine the impact of the incorporation of the measured data in the analytical model. Concurrent efforts will be made to develop variable scale imbedding techniques and an improved representation of turbulence in the planetary boundary layer. The turbulence studies will permit an improved computation of profiles of wind speed, direction, and temperature, quantities essential to the analysis of pollutant dispersal and the examination of coupled global air-sea motions. Embedding routines will provide a means of nesting solution algorithms of different scales.

W74-70451 **175-21-32**
Langley Research Center, Langley Station, Va.
EXTENDED MEASUREMENT OF ALBEDO AND TERRESTRIAL RADIATION
Eugene S. Love 703-827-2893
(160-44-63)

The principle objectives are to adopt existing methods, materials, and flight hardware to the development of an accurate, satellite system for measuring the earth heat budget. These results are important to determine the magnitude and direction of climate change (warming or cooling), and to assess the effects of pollution. It will be necessary to continue these measurements for perhaps two solar cycles (about 22 years) in order to assess both short- and long-term trends. Studies using existing data will be used in designing and planning the experiment, and data analysis. Engineering studies, environmental tests, and systems tests using existing facilities will be made to ensure that sensors and electronics will operate accurately over long periods. Plans for reducing and analyzing data over a long period will be implemented. The overguideline request will be used to acquire the services of two contractor support personnel.

W74-70452 **175-21-41**
Goddard Space Flight Center, Greenbelt, Md.
REMOTE SENSING TECHNIQUES FOR ATMOSPHERIC STRUCTURE AND SURFACE CONDITION RELEVANT TO METEOROLOGY
W. A. Hovis 301-982-6465

The purpose is to develop new remote sensing techniques for meteorological observations. Included in this effort are sensing programs in atmospheric constituents, suspended particles in the atmosphere, and surface conditions of importance to meteorology such as ocean surface temperature and roughness, and soil moisture content. New methods of multichannel remote sensing of the sea surface in the infrared and microwave spectral regions are studied to determine parameters for future spacecraft sensors and methods of reducing data from such sensors to the most accurate result. Measurements are supported with surface truth measurement and other sensors to determine atmospheric parameters such as water vapor content and particle content. Laser nephelometry is carried out in support of measurements of clouds and aerosols to provide truth for comparison with remote sensing. Soil moisture measurements utilize both microwave and infrared sensing with surface truth provided by collection and analysis of soil samples. The results of all of these measurements are used to guide specifications, integration, and data handling and processing for future experiments on spacecraft in the application program.

W74-70453 **175-21-42**
Goddard Space Flight Center, Greenbelt, Md.
TECHNIQUES FOR MEASUREMENT OF STRATOSPHERIC CONSTITUENTS
D. F. Heath 301-982-6421
(175-44-68; 175-44-64; 185-44-79)

Advanced detection and absolute radiometric calibration techniques will be developed and used for the measurement to trace constituents in the stratosphere, and absolute measurements of atmospheric radiance and solar irradiance. The research will be directed towards constituents introduced by stratospheric pollution and those natural to the stratosphere whose concentration may be altered by stratospheric pollution. The techniques developed will be used to determine the changes in space and time and to make an assessment of the effects of stratospheric pollution, and to investigate possible long term climatic changes. The initiation of supersonic aircraft flights in the stratosphere with the subsequent introduction of significant qualities of NO, H2O and particulate matter has producd a continuing need for realistic assessment of the effects of stratospheric pollution on world climatology. Some areas of special concern are reduction of the global budget of atmospheric ozone, changes in the ultraviolet atmospheric radiance and solar irradiance, and possible changes in the global cloud cover. New experimental techniques are needed to search for and to measure the concentration of trace constituents in the stratosphere utilizing both in situ and remote sensing techniques.

W74-70454 **175-21-43**
Goddard Space Flight Center, Greenbelt, Md.
SEVERE STORM SURVEILLANCE
William E. Shenk 301-982-5948

The objective is to specify sensor characteristics for the detection and surveillance of severe storms primarily from geostationary satellites with special emphasis on the identification of tornado producing thunderstorm cells. The establishment of this measuring capability is expected to be the most important item in starting a study of a SEOS satellite. Among the important sensor characteristics to be determined are the spatial resolution, spectral regions, thermal resolution (for infrared measurements), and frequency of observation. A series of aircraft flights will be conducted to investigate the cloud and atmosphere structure

prior to and during the occurrence of severe local storms. Ideally the aircraft (probably more than one) should be able to observe the top of the mature cumulonimbus cells at < 5 minute intervals and view an area of rapidly developing cells with < or = to 2 minute temporal resolution. The onboard sensors should consists of a scanning radiometer with channels in the infrared (6.7 and 11 micrometer) and a reflectance channel, and a camera with stereographic mapping capability. An observation plane is important so that the investigators can direct the movements of the high-flying aircraft above the clouds as well as photograph and monitor the cloud top profile.

W74-70455 **175-21-51**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
APPLICATION OF SATELLITE DATA TO MODELING; PREDICTING, AND MONITORING THE EARTH'S ATMOSPHERE
M. E. Alper 213-354-6948

The objectives are threefold: (1) to develop and apply improved analytical techniques to extracting earth atmospheric temperature profiles in the presence of multiple cloud layers from satellite data and to apply the resulting temperature profile to forecasting atmospheric circulation using the Goddard Institute of Space Studies (GISS) circulation model; (2) to develop new concepts for routine sounding of temperature and humidity profiles in cloudy atmospheres; and (3) to study the effect of pollutants on the atmosphere using a synthesized atmosphere model. The analytical techniques developed by Chahine for the remote sounding of the Jupiter atmosphere will be applied to the determination of temperature profiles using Nimbus and ITOS data. Long range weather forecasts will then be made employing the resulting temperature profiles and the GISS circulation model. In addition, an assessment will be made of the current atmosphere models including dispersion and transport models and wake models to provide a user catalog and to synthesize a model for pollution studies.

W74-70456 **175-21-71**
Marshall Space Flight Center, Huntsville, Ala.
CLIMATOLOGICAL-STATISTICAL ATMOSPHERIC AND CLOUD COVER MODELS
S. C. Brown 205-453-3141

Worldwide Cloud Cover Model is a statistical cloud model incorporating data on cloud amount, type, thickness, and composition. The consequence of cloud cover on earthviewing space missions is evaluated by a Monte-Carlo computer simulation procedure using the worldwide cloud cover statistics. These cloud and severe weather (thunderstorm, electrical activity, hurricanes, etc.) data contain probability distributions for various categories arranged by monthly and three hourly reference periods. To account for cloud persistence, spatial and temporal probability values are included. Simulation results are given for a specified satellite pass number. These analyses are directly applicable to Skylab, ERTS, and other Earth Resources mission analysis studies. Atmospheric data comprised of monthly means and variances were collected and anlayzed for the purpose of making electromagnetic energy attenuation predictions. While atmospheric moisture is the most important parameter, other thermodynamic quantities (pressure, temperature, and density) are included in the study. These data are being extended to a uniform altitude on a global basis. After analysis, analytical functions were fitted to these empirical data so that profiles required in attenuation computations could be internally generated by the computer. Next, a Monte-Carlo procedure will permit selection of a profile for mission simulation (mission analysis) studies. These data and the mission simulation procedures will have a direct impact on earth sensor design and selection.

W74-70457 **175-31-31**
Langley Research Center, Langley Station, Va.
MICROWAVE RADIOMETRY FOR REMOTE SENSING
G. B. Graves 703-827-3745

The objective of this work is to improve the remote sensing capability of microwave and millimeter wave devices. The general approach is to develop the techniques for the application of passive radiometry for obtaining earth resources measurements with emphasis in the area of oceanography. Research is focused on: (1) improved measurement techniques and (2) improved techniques for the analysis and interpretation of data. The scope of this work includes the development of key components such as low-noise antennas, the development of techniques for multifrequency or broadband measurements, and the development of data processing techniques and validation of analytical models for inferring physical properties from the measurement of emissions from rough surfaces such as the ocean. This work includes the acquisition and analysis of experimental data obtained in the laboratory and at remote sites.

W74-70458 **175-31-41**
Goddard Space Flight Center, Greenbelt, Md.
SPACECRAFT SUBSYSTEMS ANALYSIS AND DESIGN
John Flaherty 301-982-6862

Large aperture high resolution earth observing scanning radiometers will be used in low orbit and at synchronous altitudes. The large radiometers will be flown when the space shuttle becomes available, either on a shuttle-launched spacecraft in low orbit or by being brought to synchronous orbit by a space tug. The impact of such large sensors on the various spacecraft subsystems will be studied. The use of large mechanical scanning mechanisms has a substantial effect on the spacecraft attitude control and determination systems. The hardware requirements for attitude control to properly scan the earth and for attitude determination with accuracy comparable to the radiometer resolution will be developed. Both automated stellar referencing and earth landmark recognition systems will be used. Functional models of the hardware will be developed where feasible. The spacecraft structural requirements for supporting a large scanning mechanism without causing detrimental vibrations will be determined. The accurate referencing of the motion of the large scanning mechanism relative to the spacecraft is also necessary and high quality rate and position sensors will be developed for the scanning mechanism. The angular position of the spacecraft relative to the earth between stellar and landmark references will be determined by a high quality rate gyro subsystem. Specific scanning mechanisms will be investigated as well as spacecraft motion for scanning since this is integral with the spacecraft design. The thermal problems associated with a large aperture will be investigated.

W74-70459 **175-31-42**
Goddard Space Flight Center, Greenbelt, Md.
SPACECRAFT DATA PROCESSING
Marvin Maxwell 301-982-4036

Future earth observation spacecraft will generate very large quantities of data. This RTOP will investigate and develop systems that will provide the needed spacecraft and supporting systems to acquire, compact, process, and store this data. This first consideration is to optimize the sensor, multiplexer and ground processing elements as a total system to maximize the information to the users. Techniques are being developed to acquire and multiplex data efficiently from a variety of sensors at moderate rates (few million bits per second) for meteorological and earth survey applications and from one sensor at hundreds of millions of bits per second for high resolution earth resource applications. Magnetic tape recorder systems are being developed to provide long life and high performance spacecraft storage systems using many parallel tracks. On-board processing techniques and systems will be developed including buffer memories, multispectral data compaction systems, and on-board computers. This RTOP is in the multi-disciplinary areas of Earth Observation Satellite studies in which all of the various tasks are supporting activities in one or more of the following areas: Weather and Climate, Earth Resources Survey, Pollution Monitoring and Earth and Ocean Physics Applications.

W74-70460 **175-31-43**
Goddard Space Flight Center, Greenbelt, Md.
MICROWAVE METEOROLOGY
J. L. King 301-982-6786

The objective is to develop the microwave radiometer technology for global surveillance of storms from orbit to determine precipitation rate profiles, liquid water content, cloud height, and

cloud structure. Passive microwave instrumentation for orbital application will be developed which provide measurements of surface and atmospheric parameters for meteorological requirements. Identification, location, rainfall intensity, wind velocity and storm-systems-dynamics information outside the continental United States and especially over the oceans is only minimally available, if at all. Storm surveillance from space can provide these data for most remote and ocean regions. Storm tracking will be of great benefit in: (1) tropical storm characterization for hurricane warning and storm modification and (2) improved maritime meteorology and ship routing to avoid storms. Microwave frequencies (1.0 cm to 10 cm) are most widely used for meteorological probes. They interact strongly with precipitation while undergoing relatively slight attenuation by the gaseous and charged components. Visible and infrared sensors were the first used for earth observation because convenient, small, lightweight---

W74-70461 **175-51-41**
Goddard Space Flight Center, Greenbelt, Md.
PROCESSING SYSTEM STUDY
T. J. Karras 301-982-6335

The objective is to define the components, integration and performance of a system capable of extracting atmospheric and oceanographic information from satellite observations and displaying this information in a format which is of maximum benefit to the users. The primary purposes of this system are as follows: (1) generation of images resulting from low resolution scanning microwave and optical spectroradiometers flown on future earth observation satellites; (2) extraction of atmospheric and oceanographic parameters (winds, temperature, moisture, color, roughness) from satellite earth observations for R and D purposes. (3) products (images, maps, plots) generated as a data base for analysis by users and investigators; and (4) analysis of extracted parameters and applications to research dealing with atmosphere and oceans (e.g., analytical displays of ocean currents, river discharge plumes, air circulation relating to severe storms, and tropical convection).

W74-70462 **175-61-41**
Goddard Space Flight Center, Greenbelt, Md.
ANALYSIS OF THE ENERGY INTERACTIONS BETWEEN ATMOSPHERIC LEVELS AND OF SOLAR TERRESTRIAL RELATIONSHIPS
D. F. Heath 301-982-6421

The interactions of mechanical, radiation, and chemical energies between the lower and upper regions of the atmosphere, and its interaction with solar radiation and distribution of minor constituents are investigated. This encompasses absorption, scattering, and emission of solar and atmospheric radiation by constituents of the stratosphere and mesosphere. The photochemical and chemical reaction in the upper atmosphere, horizontal and vertical transport processes, gravity waves, turbulence, and tides originating in the lower atmosphere are also studied. Measurements of the absolute solar irradiance and the solar constant from balloons and high altitude aircraft will be made in a search for solar variability over a period of the 11 year solar cycle. Relatively little is known of the abundance of ozone, water vapor, and other trace constituents, and absorption of solar energy with wavelength and altitude through the stratosphere. Observations with the MUSE experiments of Nimbus have indicated a significant 11 year solar cycle variation in the solar irradiance below 2000 A. The precise nature of the variation of solar irradiance at the longer wavelengths can be established with high altitude balloon and aircraft flights. Previous works which tried to detect variability in the solar constant or irradiance were hindered by poor absolute spectroradiometric standards and the inhomogeneity of the terrestrial atmosphere. New absolute spectroradiometric calibration techniques will be used to calibrate the measurements of the solar constant and irradiance in the wavelength region which is important in measurements to be utilized in climatological---

W74-70463 **175-61-41**
Goddard Space Flight Center, Greenbelt, Md.
TECHNIQUES FOR UTILIZING SATELLITE OBSERVATIONS IN METEOROLOGICAL APPLICATIONS
R. Wexler 301-982-2188
(175-44-58; 175-44-63; 175-44-69)

The objective is to apply satellite observations to the quantitative measurements of meteorological phenomena. Specifically, the satellite data are applied to determine sea surface temperature, the location of rain area, vertical distribution of atmospheric temperature, humidity, and ozone, and cloud motions (winds) from geostationary satellites. Applications of these derived parameters may then be made to studies of mesoscale systems, planetary scale phenomena, stratospheric circulation, the radiation heat budget, and climatic change. Special focal points of this research are the establishment of a basis for the specification of the remote sensing part of the global meteorological observing system required for large-scale, long term weather forecasts (viz. the Global Atmospheric Research Program - GARP), and, similarly, the establishment of a basis for the specification of a system for continuous observations of weather features so that these observations can be applied to short-term weather forecasts.

W74-70464 **175-61-61**
Wallops Station, Wallops Island, Va.
OZONE MEASUREMENTS
J. F. Spurling 703-824-3411

The objective is to improve techniques for the measurement of ozone. The approach is to: (1) improve the methods of evaluation of remote optical measurement of ozone and other atmospheric trace constituents by improved utilization of the theory of atmospheric transmission of light; (2) evaluate and intercompared satellite-borne, aircraft-borne, balloon-borne, and ground-based sensors for the measurement of ozone; (3) develop system design parameters for routine synoptic measurement of total atmospheric ozone and vertical ozone profile; and (4) to utilize the ground-based on balloon-borne ozone measurement systems to provide truth data for the calibration and validation of rocket and satellite-borne ozone sensors. An example is the Limb Radiance Inversion Radiometer (LRI), scheduled to fly on Nimbus F in 1974 and measure ozone profiles in the region from 15 to 50 kilometers.

W74-70465 **175-61-71**
Marshall Space Flight Center, Huntsville, Ala.
INTERRELATIONS BETWEEN ATMOSPHERIC MOTIONS OF DIFFERENT SCALES
R. E. Turner 205-453-3109

Past research has demonstrated the existence of significant relationships between small size systems which are detectable in synoptic data and sub-synoptic or mesoscale systems. The results show the relationships are complicated and depend on the four-dimensional structure of the entire atmosphere from the stratosphere to the ground. The best and most promising approach is to define small-scale synoptic systems and then relate these systems to weather events. This approach will allow an attack on the problem on a theoretical basis using principles of hydrodynamics, kinematics, and thermodynamics. In numerical weather prediction models, systems with a dimension of less than approximately 500 km are assumed to be functionally related to larger scale or mean motions. The proposed research is to investigate the relationships that exist between mesoscale atmospheric phenomena and larger-scale averages of the same or related phenomena. In addition, the atmospheric structure derived from polar orbiting and geostationary satellite remote sensing measurements will be assessed relative to applicability of mesoscale structure definition. This will be revealed by selected atmospheric variability experiments involving radiosonde, rocketsonde, and satellite soundings data sets.

W74-70466 **175-61-72**
Marshall Space Flight Center, Huntsville, Ala.
AUTOMATIC CHANGE DETECTION OF METEOROLOGICAL/ATMOSPHERIC PHENOMENA FROM SATELLITE DATA
R. R. Jayroe 205-453-2553
(160-44-69)

The objectives are to: (1) fully exploit the advantages of new data management concepts for the assessment of automatic change detection of meteorological phenomena from satellite data;

and (2) continue to develop and implement mathematical schemes and computer procedures to demonstrate the value of automatic meteorological/atmospheric (air quality) change detection using data from SMS, Tiros, and Nimbus satellites. These techniques will detect discrete changes of features as well as continuing incremental growth changes or stress type changes within a given feature. The approach will be to: (1) develop, evaluate, and implement automatic change detection computer techniques; (2) develop an operational computer program to automatically register the meteorological/atmospheric changes in satellite images; and improve the present multispectral classification programs and develop the change detection techniques compatible with the needs of operational satellite data users. This effort is in direct support of NASA's Meteorological Program objectives: M1 Operational Satellites, M2 Storm Warning, and M6 Processes and Interactions.

W74-70467 **175-61-73**
Marshall Space Flight Center, Huntsville, Ala.
ANALYSIS OF THE ENERGY INTERACTIONS BETWEEN ATMOSPHERIC LEVELS AND OF SOLAR TERRESTRIAL RELATIONSHIPS
R. E. Smith 205-453-3149

The objectives are to establish a unified mesosphere model of the flow field (wind) and the state variables (pressure, temperature, and density) which is consistent with acceptable physical constraints and statistical principles and to obtain relative estimates of the magnitude and structure of gravity waves and turbulence by a detailed analysis of rocketsonde measurements. Errors in the measurements must be treated as an integral part of the analysis to separate the effects due to measurements from those due to natural phenomena. Another objective is to study propagation of waves through upper mesosphere and lower thermosphere by comparing results from a theoretical model with observations from operational equipment consisting of a C-4 Ionosonde, Phase-Path Sounder, CW Doppler Array, and an Airglow Observatory. This effort is in direct support of NASA's Meteorology Program Objective M6 Processes and Interactions.

W74-70468 **175-91-11**
Ames Research Center, Moffett Field, Calif.
AIRCRAFT SUPPORT OF THE METEOROLOGY PROGRAM
Glen Goodwin 415-965-5065

This RTOP is to provide an airborne platform, carrying instrumentation for meteorological measurements. Experiments will be mounted and flown aboard the Convair 990 (NASA 711) to conduct basic meteorological studies and to support satellite instrumentation development and data analysis. A necessary first step in the development of satellite instrumentation for remote sensing of the earth and atmosphere is to obtain information basic to the understanding of factors influencing the spectral signals to be observed from space. This information must be obtained aboard aircraft because measurements must be made from the ground to the stratosphere with speed and flexibility in geographical location to obtain data under the many desired meteorological conditions. Scales ranging from local to global are amenable to study by an aircraft such as the CV-990.

W74-70469 **175-91-41**
Goddard Space Flight Center, Greenbelt, Md.
SYSTEMS AND MISSION ANALYSIS OF METEOROLOGY PROGRAM ELEMENTS
Charles R. Laughlin 301-982-6291

The objectives are to study and analyze advanced techniques for meteorological observation systems in areas under the cognizance of the System and Mission Analysis Group of the Meteorology Program Office. Results will be used in performing evaluations, providing recommendations, and developing future plans for NASA's weather and climate mission and programs. Emphasis will be placed on selected areas of particular importance to future programs. Study will be focused on: (1) new technology already emerging so as to expedite applications of these developments; and (2) future requirements as provided by the user community so as to identify areas requiring initiation of new technology developments. Functional expertise available at GSFC and other Centers involved in weather and climate activities will be drawn on to the maximum extent possible. Quick-reaction task order contractors will be utilized for support of these activities for technical writing/editing, preparation of visual aid materials, and other resources not otherwise available. Studies will be focused on the forefront of and beyond present capabilities, and aimed at capitalizing on advanced and creative endeavors wherever they may be found. Therefore, it is expected that as areas requiring initiation of new technology are identified, it will become necessary to utilize contractor support to perform specialized investigations where in-house resources either do not exist or cannot be developed expeditiously and efficiently.

W74-70470 **175-91-42**
Goddard Space Flight Center, Greenbelt, Md.
EARTH OBSERVATIONS LABORATORY, FIELD EXPERIMENTS, AND CALIBRATION OF RADIATION SENSORS
W. A. Hovis 301-982-6465

The objective of the effort conducted under this RTOP is to provide laboratory calibration facilities, sensor evaluation and test and to conduct field programs where new concepts in meteorological remote sensing are demonstrated prior to flight on spacecraft. An in-house calibration facility is maintained and continually updated to provide calibration support to both field projects and spacecraft sensor projects. The present capability extends to sensors with up to 46 cm diameter aperture and will be increased to meet the demand for larger aperture sensors. Calibration sources and consultation are supplied to projects such as SMS VISSR, Nimbus SOMR, SCR and HIRS and ITOS VHRR. Laboratory measurements are made of the basic properties of natural materials in the microwave spectral region utilizing in-house radiometers at various frequencies. The laboratory measurements are made of the basic properties of natural materials in the microwave spectral region utilizing in-house radiometers at various frequencies. The laboratory measurements are utilized to guide development of aircraft and eventually spacecraft-borne microwave radiometers. Aircraft field measurements are made to verify remote sensing techniques and to provide data handling experience before spacecraft flights. The sensor field experiments on aircraft are supported with data processing equipment, digitizers, tape recorders, auxiliary sensors, and aircraft housekeeping recorders that are common to any aircraft field program.

W74-70471 **175-91-43**
Goddard Space Flight Center, Greenbelt, Md.
TECHNOLOGICAL AND RESOURCE ANALYSIS OF METEOROLOGICAL PROGRAM ELEMENTS
E. A. Neil 301-982-6291

The purpose of this RTOP is to provide financial support to the Meteorology Program Office (MPO) in the conduct of its business in support of the Office of Applications and the various program offices represented. Funding will be utilized through in-house and available support services contractors, for selected efforts in fulfilling the objectives of the MPO as defined in the proposal dated July 10, 1972 covering the formation of the MPO at GSFC. In general, efforts will be devoted to technical reports, charts and related artwork, presentation material, reports and specialized analyses. Support will also be provided as necessary for meetings and/or symposia having a programmatic input. The special analysis would include but not be limited to surveys and documentation of proposed future instrumentation, long range system planning and system constraints, cost estimating and cost modeling techniques, and planning documentation such as shuttle utilization and/or optimum future operational system needs. The attached T-8's specify initial tasks for such studies.

W74-70472 **176-11-11**
Ames Research Center, Moffett Field, Calif.
LABORATORY INVESTIGATION OF MINOR ATMOSPHERIC CONSTITUENTS
Glen Goodwin 415-965-5065

The objectives of this work are to provide the spectroscopic data needed for the detection and quantitative abundance determination of minor constituents in the earth's atmosphere and to develop new techniques for remotely sensing minor atmospheric constituents and pollutants. The gases to be studied

will include pollutants such as NO2, SO2, CO, and O3. High resolution grating spectrometers and interferometer spectrometers will be used in conjunction with a variety of existing absorption cells to measure the absorption spectra of the minor constituents. Data obtained in the laboratory will be used: (1) to interpret the spectra of gas samples obtained via horizontal and vertical aircraft flights and (2) to define the spectral region(s) most useful for remote sensing techniques.

W74-70473 **176-11-61**
Wallops Station, Wallops Island, Va.
LABORATORY INVESTIGATIONS OF MINOR ATMOSPHERIC CONSTITUENTS
Shardanand 703-824-3411
(185-47-94)

The objective is to carry out an integrated laboratory study in order to provide the spectroscopic data that are required to detect and quantitatively determine the amounts of minor constitutents in the earth's atmosphere. In the later part of the program the development of new techniques of measuring the minor species may be undertaken. The basic technique used in measuring these species is to monitor the transmitted or scattered radiation (Ramna, resonance-fluorescence) through the atmosphere assuming that the species are in equilibrium. For this, reliable spectroscopic data, such as: absorption and scattering (Rayleigh, Raman, resonance-fluorescence) coefficients are required. Although the bulk of absorption coefficient data for most of the individual gases do exist, a careful consideration is required in their use when more than one gas are simultaneously present and subject to photochemical changes. However, knowledge of photon scattering (Rayleigh, Raman, resonance-fluorescence) is very meager. Therefore, we intend to obtain the absorption data in simulated conditions of photochemical equilibrium (dynamic and/or static) for chemically active constituents (NOx, SO2, O3, O2...). For this purpose the multiple gas cells in series which can be connected to each other for reactions to occur will be utilized. The study of photon scattering will also be an integral part of this program to obtain the spectroscopic data of electromagnetic radiation interaction with atmospheric constituents.

W74-70474 **176-13-32**
Langley Research Center, Langley Station, Va.
REMOTE SENSING: FRESH WATER AND LAND POLLUTION; BIOTIC AND ABIOTIC DEGRADATION, ENERGY BUDGET AND CULTURAL PRESSURE
Eugene S. Love 703-827-2893
(160-75-18)

This RTOP covers planning activities to be carried out during FY-74 for the purpose of defining an expanded LaRC program on the application of remote sensing to fresh water and land pollution. This work is related to existing LaRC work in this area, including studies of the applicability of remote sensing to problems of acid mine drainage and lake eutrophication. Work carried out under this RTOP number in FY-74 will be continued in FY-74 under 160-75-18.

W74-70475 **176-14-31**
Langley Research Center, Langley Station, Va.
INFORMATION EXTRACTION TECHNIQUE DEVELOPMENT
Eugene S. Love 703-827-2893

The objectives of this work are twofold: (1) to develop techniques for deriving the maximum possible information on pollution distribution from satellite data while minimizing the data storage requirement; and (2) to assess and minimize agency-wide and LaRC investment in ground data management equipment, facilities, and personnel through selection of the most cost-effective data management system concept. The spacecraft systems to be considered include ERTS, Nimbus G, Global Environmental Monitoring Satellite (GEMS) and the Advanced Technology Laboratory (ATL). Thus, this effort is directed towards attacking the data management problem for earth resources experiments by maximizing the data usage and by minimizing the hardware and software requirements. Maximizing the use of data includes, for example, the statistical interpretations of measurements of vertically integrated air pollution, such as would be produced by the Nimbus G or GEMS. Other information (such as meteorological data, pollution dispersal model, and a pollution source inventory) must be coupled with the satellite data to achieve the end objectives of the program--pollution monitoring and source location. The ground data management system will initially be attacked by examining the LaRC ATL earth resources experiments in detail to determine the data management system requirements from data acquisition through dissemination. The study will evaluate alternate concepts derived from analysis of data reduction requirements, assessment of LaRC's data reduction and processing capabilities, and investigation of present and projected agency capabilities.

W74-70476 **176-21-31**
Langley Research Center, Langley Station, Va.
ATMOSPHERIC POLLUTION SENSING
G. B. Graves 703-827-3745
(630-52-00)

The objective of this work is to develop techniques and sensors to measure atmospheric trace constituents, both gaseous and particulate. The primary emphasis is on development of remote sensors for measuring pollutant distributions over regional and global areas from airplanes and satellites. In situ sampling techniques are included to provide improved ground-truth measurements for flight tests of remote sensors. Analysis techniques for atmospheric particles are included to study the origins of the aerosols at different altitude regimes. The research on passive remote sensors operating in infrared and microwave spectral regions requires that the spectral signatures of the important trace constituents and interfering gases be accurately determined, and work is underway on the signatures of NO2 and NHO3. An engineering model of a nondispersive gas filter correlation analyzer to measure CO was test flown in FY-73, and will be modified to measure SO2 in FY-74. Ground modulation effects on correlation interferometers will be studied in FY-74, and analytical feasibility studies of a scanned, side-looking gas filter radiometer to measure vertical profiles of gases whose concentration is in the parts per billion range, will be undertaken. Studies to relate remote scattering and polarization measurements to atmospheric aerosol parameters are included. The work on in situ sensors includes laboratory studies to establish the feasibility of microwave resonance spectrometers for SO2 and NH3, and on samplers and chemical analysis techniques for atmospheric particles.

W74-70477 **176-31-51**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
ATMOSPHERIC POLLUTION SENSING: HETERODYNE SPECTROSCOPY
Donald P. Burcham 213-354-3028
(160-44-78; 645-40-03)

The general objective is to develop sensing systems which utilize infrared laser technology for remote monitoring of atmospheric pollutants from aircraft and spacecraft altitudes. The systems under investigation and development are of both passive and active types. They will provide certain capabilities which are not presently available using passive radiometers or solar absorption spectrometers. The instrument presently being used for ground based remote sensing is an active laser absorption spectrometer, using a narrow bandwidth heterodyne radiometer as a receiver. Utilizing previously determined spectral overlaps between certain emission lines of CO2 and CO molecular lasers and pollutant absorption lines, the plan is to initially use this instrument as a monitor of NO, O3, and SO2. A closely related passive heterodyne radiometer, using a wider IF band width, has also been developed. The goals for FY-74 are to test the operational capabilities of both the active and passive systems while monitoring pollutants under various atmospheric and background conditions, preparing in this way for flight operation. Conditions simulating the flight situations, will be used as much as possible. Design of an instrument which is suitable for aircraft flights in FY-75 will follow. The eventual goal is to develop an instrument which will be suitable for use on spacecraft, e.g., a shuttle mission. Concurrent analysis will continue on the potential of other remote sensing systems which make use of laser

technology and appear to offer advantages over present instruments.

W74-70478 **176-52-21**
Lewis Research Center, Cleveland, Ohio.
REMOTE SENSING: FRESH WATER AND LAND POLLUTION
Herman Mark 216-433-6201

The objectives are to detect, identify and monitor, by remote sensing techniques, land pollution due to stripmining of coal, and to determine the contribution to the degradation of streams due to run off from this polluted land (toxic spoilbanks). Optimum techniques for stripmining and land rehabilitation monitoring will eventually be transferred to ERTS-1 satellite.

W74-70479 **176-53-11**
Ames Research Center, Moffett Field, Calif.
REMOTE SENSING OF EUTROPHICATION AND OTHER LAKE PROCESSES
Glen Goodwin 415-965-5065
(160-75-17)

The objective is to study lake eutrophication and associated processes in California in cooperation with Federal, State and local agencies by means of remote sensing (satellite and aircraft) in conjunction with water property measurements to provide the synoptic and sequential coverage necessary to understand whole lake processes to the extent required for monitoring and control. Processes in Lake Tahoe, Lake Berryessa and Clear Lake will be studied using ERTS 1 and B and aircraft remote sensing techniques (multispectral images, color images, chlorophyll detection, thermal images, multispectral and polarized video images) coordinated with water property studies. Studies at Lake Tahoe will continue to concentrate on bio-stimulation of sediment plumes and other nutrient imputs during snowmelt periods and after rainstorms. Investigations at Lake Berryessa will involve studies of sediment sources, the distributions of suspended sediment in the lake and circulation dynamics of the lake with an aim toward understanding sources, causes and effects of siltation-induced degradation of water quality and, eventually, storage capacity. Studies at Clear Lake are directed toward first documentation of the time and spacial sequence of noxious (blue-green) algal blooms in this naturally eutrophic lake, secondly relating these blooms to nutrient sources and/or physical conditions and finally, to test aeration control measures designed to inhibit development of floating noxious algal mats.

W74-70480 **176-53-21**
Lewis Research Center, Cleveland, Ohio.
MARINE POLLUTION MONITORING AND ASSESSMENT
Herman Mark 216-433-4000

The objectives are to develop remote sensing systems for monitoring water quality and for limnological measurements in the Great Lakes. The systems to be developed are to be applied to entire Great Lakes bodies to fully utilize the synoptic advantages of remote sensing. Observations by aircraft and by the Earth Resources Technology Satellite (ERTS) of the spectral response (visible and IR) of the lakes with special emphasis on Lake Erie will be correlated with water sample measurements made at the surface and at several depths including the lake bottom. Correlation of the remote sensing data with biological, chemical and water current models will be made to demonstrate the utility of the remote sensing systems. The main objective of the systems are to provide data which can aid in the management of the Great Lakes water resources including the specification of pollution restrictions. Because of this objective the systems will be developed in cooperation with the Environmental Protection Agency (EPA), NOAA and the Canada Centre for Inland Waters. Once developed it will be turned over to them for their own use.

W74-70481 **176-53-32**
Langley Research Center, Langley Station, Va.
MARINE POLLUTION MONITORING AND ASSESSMENT
Eugene S. Love 703-827-2893

This RTOP covers cooperative work with with user marine institutions to quantitatively measure the ecological consequences of specific man-made and natural pollutants in estuaries of the Chesapeake Bay and in the adjacent coastal zones. Work includes evaluation of remote sensing and remote readout instrumentation for applicability to marine pollution measurement, study of oil spill effects, study of trace organic compounds in the air, water, and biota of the marine environment, and studies of biological systems to monitor effects of pollution. Satellite and aircraft data will be employed to correlate remote data with sediment transport, chlorophyll concentration, and bathymetry of selected areas in the Chesapeake Bay. Samples taken from air, water, sediments, and marine biota are analyzed for trace synthetic organic compounds, in parts per billion, using advanced sampling and concentrating techniques in conjunction with microwave spectrometry to assess the effects of these organic compounds on marine ecology. A new technique for coliform detection and techniques for instrumenting shellfish as pollution indicators, both applicable to remote readout, will be explored.

W74-70482 **176-53-71**
Marshall Space Flight Center, Huntsville, Ala.
REMOTE SENSING: FRESH WATER AND LAND POLLUTION; BIOTIC AND ABIOTIC DEGRADATION, ENERGY BUDGET AND CULTURAL PRESSURES
H. G. Hamby 205-453-0889
(160-75-34; 160-75-10; 160-75-86; 160-75-30; 160-75-99)

The objectives are: (1) to establish in controlled laboratory remote sensing tests basic capabilities of state of the art sensing systems to measure water quality parameters in polluted turbid waters typical of the Tennessee River; (2) to establish a definition of the optimum role of in situ instrumentation used in support of remote sensing and to conceptualize a prototype system of instrumentation; (3) to adapt an ERTS DCP buoy for use in real-time monitoring of water quality and use it for a prototype remote/in situ system evaluation to determine the most cost-effective use of remote sensing techniques; (4) to establish with industrial and regulatory agency users, among others, a system for utilizing remotely- and in situ sensed water quality parameters in controlling the release of effluents into streams, rivers and estuaries in Alabama; and (5) to examine the potential of remote sensing for detecting aquifers in limestone cavities which are potential contamination sources as a result of established waste control techniques in Alabama. Activities under associated RTOPs and ERTS 1 an EREP experiments will be utilized; these will be augmented by laboratory work to answer certain questions raised in examination of ERTS 1 and other remotely-sensed data. Through established user/partner relationships with local, state and federal agencies working on water quality problems in Alabama, the techniques of remote sensing and in situ monitoring will be combined, supplemented by an information system, and put to use in a real-life situation.

W74-70483 **176-61-11**
Ames Research Center, Moffett Field, Calif.
GLOBAL STUDY OF STRATOSPHERIC CONSTITUENTS
Glen Goodwin 415-965-5065

Long range goals are to reach as complete an understanding as possible of stratospheric air chemistry and physics by making physical measurements in the stratosphere and by developing computer models of the chemistry, transport and radiative effects in those regions. Specifically, we propose to establish a global bench mark as a background against which to compare future measurements and evaluate the effect on stratospheric structure of artificial perturbations (e.g. space shuttle, SST). Airborne measurements of stratospheric minor constituents including particles in the 0.1 to 1 micron range will be carried out over large geographic areas using aircraft capable of flying in the stratosphere. The measurement of most of the materials of interest (O3, H2O, CO, CO2, SO2, NO, aerosols) is currently within the state-of-the-art. An instrument package has been assembled using commercially available items. Flight tests in the CV-990 have begun. When the package is working satisfactorily, operations using the U-2 aircraft will begin. A sampling program will be designed and carried out to provide the desired air chemistry data, and the data so obtained will be correlated with model studies in order to meet the objectives of the program. In order to fully utilize the results of the experimental program, it is

necessary to employ them in model studies of the stratosphere. These will be of two types: (1) chemistry and transport studies of minor atmospheric components in order to develop their spatial distributions for various realistic sources; and (2) radiative balance studies to evaluate the long term effect of gaseous and particulate contaminants on global climate.

W74-70484 **176-91-31**
Langley Research Center, Langley Station, Va.
ENVIRONMENTAL QUALITY ENHANCEMENT PROGRAM
Eugene S. Love 703-827-2893

The purpose of this RTOP is to plan and implement the Atmospheric Quality Enhancement program. The long range goal of this program is to cooperate with user agencies in applying NASA technology to assess the state of the environment and to evaluate the future impact of candidate strategies for enhancing the quality of the earth's atmosphere. NASA's experience in a number of disciplines, i.e., measurement techniques and sensors, data management and analysis, will be used to assist the users in defining their needs for synoptic measurement of air pollution and in defining the roles of satellites, and aircraft remote sensing and ground based measurements to meet user needs. Additionally, NASA plans to utilize its expertise in synthesizing physical systems, a factor of great importance in development of environmental models, to assist in understanding the impact of pollution source abatement, meteorology and other factors on both regional and larger scales.

W74-70485 **176-91-51**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
MEASUREMENT OF POLLUTANTS IN AN URBAN ENVIRONMENT
Donald P. Burcham 213-354-3028

The primary objective of this research is to perform experimental studies addressing a specific current problem with respect to establishment of air quality standards, which are germane to NASA's role in supporting the government's effort in obtaining environmental air quality. In additional to meeting this more immediate objective, the work will also lead toward a better understanding of experimental techniques required for the remote sensing from satellite platforms of atmospheric constituents of importance to air quality. The objectives will be met by conducting a program of survey flights from an aircraft with a remote sensing infrared interferometer spectrometer developed by JPL under the AAFE program. This high throughput and high efficiency instrument, the High Speed Interferometer (HSI), has been designed for aircraft operation, and has performed local surveys of stratospheric trace constituents during flights on board an Air Force NC 135 in February/March, 1973 and aboard the French SST Concorde in May/June 1973. While those observations were made by observing the Sun near the horizon, the measurements to be made for this research will result from analysis of spectra obtained in the same wavelength region (1.2 to 5.3 microns) but looking at solar radiation reflected from the ground and energy emitted by the surface. This measurement technique was successfully demonstrated in the concluding phase of the AAFE program, when the HSI was flown aboard the Goodyear airship Columbia over downtown Los Angeles. Concentrations of pollutants in the lower troposphere, such as NOx, N2O, CO, CO2, and low level hydrocarbons as well as the more common molecules like H2O and O3 will be determined to accuracies in the 10 to the minus eighth power to 10 to the minus tenth power range.

Earth Resources Survey SR&T

W74-70486 **177-11-11**
Ames Research Center, Moffett Field, Calif.
RESEARCH AND TECHNIQUE DEVELOPMENT FOR OPTIMUM DATA FLOW
J. M. Deerwester 415-965-5897
(160-20-64)

The objective of this RTOP is to develop an understanding of the flow of earth observation data from the onboard sensors to the user, sufficient to identify technical problems, long lead time items, required technology developments, and other system issues needing resolution, such as whether users will interact with the system in real time. Complete data flow plans will be formulated and optimized. Broad functional requirements for subsystems will be specified and a project plan for proper phasing of the various analyses, technology developments, hardware procurements, and other system development steps will be prepared. Interagency interfaces will also be considered. In-house analysis will be used to identify issues needing tradeoff studies or in-depth analyses; out-of-house contracts will be used to resolve these key issues. Pilot studies will be performed to resolve questions of feasibility of alternative approaches. Data flow plans will be synthesized through in-house activities supported by specific analyses performed under contract.

W74-70487 **177-11-81**
Lyndon B. Johnson Space Center, Houston, Tex.
DEVELOPMENT OF PROCEDURES FOR ASSESSMENT OF VALUE AND COSTS OF INFORMATION TO USER
R. Bryan Erb 713-483-4623

This RTOP is to provide potential users of remotely acquired information a basis for comparing the cost and value of remotely acquired data applicable to a problem to the value and cost of the data acquired to approach the problem in a conventional manner. Guidelines for determining the most effective balance of remotely acquired and conventional observations and statistics, for performance of a defined task in general will be developed. The initial effort will be development of rationale of weighing information value in terms of user needs and applying this rationale to the determination of cost-value trade-offs of remotely acquired and conventional data based information. These will be demonstrated for one or more applications in cooperation with the user.

W74-70488 **177-22-41**
Goddard Space Flight Center, Greenbelt, Md.
VISIBLE AND IR SENSOR SUBSYSTEMS
Harvey Ostrow 301-982-4107

High performance image systems are required for future earth survey missions, such as EOS and SEOS. Increased spatial and spectral resolution, response into the emissive IR and inherent registration between spectral channel are required. The desired characteristics can be achieved by development of suitable new sensors, such as large photosensor line arrays for both the visible and IR spectral regions and advanced scanner systems. Solid state linear arrays with thousands of elements can be assembled. By using multiple arrays, registered high spatial resolution images can be obtained without using mechanical scanning techniques. CCD array technology also offers the possibility of significant improvement in the sensitivity and reduction in system complexity. Scanning spectro-radiometers can provide radiometrically accurate data from the visible through the emissive IR region, but additional development is required to obtain resolution improvements over the ERTS MSS by a factor of two or better. Other advanced image sensor techniques appear applicable. One technique uses an optical filter to multiplex spectral channels, while using a single detector, such as a vidicon. This technique is now being used in some ground based applications and provides inherent registration. The extension of the technique to earth observation systems will be pursued, as will the development of display systems for use with the sensors being developed for future earth survey missions. Thirty percent of the effort in this RTOP is addressed to the Weather and Climate Discipline and 70% is addressed to the Earth Resources Survey Discipline.

W74-70489 **177-22-81**
Lyndon B. Johnson Space Center, Houston, Tex.
VISIBLE-INFRARED SENSOR SYSTEM TECHNOLOGY DEVELOPMENT
Richard R. Richard 713-483-4661

An activity will be undertaken to upgrade several technical areas critical to the performance evaluation or improvement of remote sensing technology used in the Earth Resources Aircraft Program in the ultraviolet, visible, and infrared spectra. A study will be conducted to determine which solid-state technology best

satisfies both the spatial and spectral requirements of the Scanning Imaging Spectroradiometer (SIS) developed for the Earth Resources Program. The results will be applied to a development which demonstrates the feasibility of solid-state imagers in this application. Methods and procedures will be developed for calibration in the ultraviolet, visible, and infrared regions with general applications to remote sensors but specifically applicable to the Multispectral Scanner System (MSS) used in the EOAP with goals of providing traceability to NBS. Techniques will be developed for end-to-end remote sensor performance evaluation in an operational environment. The techniques will have general applicability but will apply specifically to the 24 channel Multispectral Scanner used in the EOAP. Sensors will be developed which provide multiple spectral response at a single focal point. Layered or sandwich techniques will be evaluated wherein the upper detector is transparent to the responsive wavelengths of the lower detector. New materials will be used for the fabrication of detectors providing substantial advantages in performance or reliability. Specific candidates are lead-tin-telluride and pyroelectric detectors although other materials and processes will be considered.

W74-70490 **177-22-82**
Lyndon B. Johnson Space Center, Houston, Tex.
COMPARISON OF PERFORMANCE OF ACTIVE AND PASSIVE MULTISPECTRAL SCANNERS
A. E. Potter 713-483-2071

The objective is to define the advantages and disadvantages of an active multispectral scanner (laser line scanner) relative to the commonly-used passive scanner. Accuracy of automatic computer identifications, and general characteristics of aircraft and spacecraft systems are to be defined. The approach will be to use existing sets of data collected with the ERIM active scanners. Selected data sets will be analyzed to demonstrate capabilities for automatic computer identification. Analytical calculations will be performed to define size, power requirements, resolution, etc., for high-altitude aircraft and spacecraft active scanners.

W74-70491 **177-23-61**
Wallops Station, Wallops Island, Va.
INFORMATION EXTRACTION TECHNIQUE DEVELOPMENT
H. E. Maurer 703-824-3411

Information extraction techniques will be developed to make optimum use of synthetic aperture radar data for earth observations applications, and to correlate this information with information extracted from earth observations data acquired of the same scene by other remote sensors. Synthetic aperture radar data will be acquired by the Wallops C-54 based radar and registered and displayed with remote sensed earth observations data acquired of the same scene. The onboard vs. ground data processing requirements will then be studied.

W74-70492 **177-23-81**
Lyndon B. Johnson Space Center, Houston, Tex.
EARTH OBSERVATIONS RADAR WORKSHOP
R. A. Moke 713-483-6357

The purpose is to conduct a review of active microwave sensors with applications to earth observations, leading to recommended program activities in advanced sensor development that provide the best balance between user objectives and sensor technology. The objective of the workshop is to inform user groups of the scope of the NASA effort in the field of active microwave systems, and to obtain a critical review of these efforts from the workshop participants. By means of an interchange of ideas between the technical and user communities, it is hoped that NASA will more effectively apply its efforts in developing advanced remote sensing instruments. More specifically, efforts will be made to: (1) provide brief descriptions of work accomplished to duate in applications of radar data to earth observations, also those investigations and/or studies presently in progress; and (2) provide a description of the state-of-the-art active microwave systems, projection of the 1980 class of instrument capability, and to highlight the areas of uncertainty or problems requiring emphasis.

W74-70493 **177-25-51**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
DATA MANAGEMENT AND STORAGE
Robert V. Powell 213-354-6586

Advanced data management and processing system technology will be developed to satisfy future Earth satellite requirements. The work will be performed in the areas of reliable tape recorders, data compression algorithms, and spacecraft measurement system technology. Specifically, the work will: (1) complete the work on a long-life hydrofilm tape transport initially started with OSS funds; (2) develop an adaptive, high-performance data-compressor/decompressor system suitable for multispectral redundancy elimination, as well as suitable for television picture bandwidth reduction; and (3) develop preliminary designs of a computer-aided telemetry system. It is planned to demonstrate the feasibility and utility of these designs by the end of fiscal year 1975. These advanced development activities will be performed in-house by personnel who have developed innovative solutions to similar problems related to advanced planetary missions.

W74-70494 **177-26-41**
Goddard Space Flight Center, Greenbelt, Md.
SENSOR CALIBRATION, TEST AND SIMULATION
W. A. Hovis 301-982-6465

The objectives of this effort are to provide calibration support for earth observation sensors in the applications program; to devise and produce new calibration devices for new, advanced sensors of large aperture; and to extend the spectral range of calibration to accommodate new areas of interest such as ocean color sensing. New sensor techniques are developed and tested and spacecraft sensor performance simulated to guide development of spacecraft sensors. The radiance standards of the National Bureau of Standards are utilized to calibrate sources compatible with large aperture scanners made to view extended sources. These sources are then provided to applications satellite programs such as Nimbus G, ERTS, and EOS to assure commality of calibration and intercomparability of results. Calibration sources for spacecraft sensors are evolved from the laboratory experience and new problems in sensor technology such as elimination of polarization sensitivity are studied using breadboard sensors before flight sensor construction is begun.

W74-70495 **177-31-41**
Goddard Space Flight Center, Greenbelt, Md.
ADVANCED IMAGE PROCESSING TECHNIQUES
W. L. Alford 301-982-5515
(310-40-39)

The objective of this RTOP is to develop new systems and techniques for image processing and analysis. Techniques will be investigated that will lead to the generation of more useful image products such as image mosaics and enhanced images. Emphasis will also be placed on the development of efficient digital image processing algorithms and systems that do not require very large digital computers to keep up with the anticipated results. These objectives will be approached using a combination of in-house research, university grants, and contracts. Some of the results will be in the form of reports, hardware, or computer programs. One of the in-house tools which will be used (and refined under one task in this RTOP) is the Image Display And Manipulation System (IDAMS), an interactive image processing and analysis system.

W74-70496 **177-31-51**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
EARTH RESOURCES GEOLOGY/GEOMORPHOLOGY
Donald P. Burcham 213-354-3028

Regional geologic and geomorphic problems will be approached on a regional scale using analysis of ERTS and aircraft images as an adjunct to standard photogeologic methods. Better discrimination among geologic units will be attempted using multispectral and multipass ERTS and aircraft images. Ground truth spectro-radiometry using the backpack field spectrometer already developed will be correlated to the lower resolution S/C images. Current ERTS data analysis has shown the possible application of ERTS and aircraft data to the search for ground

water in central Arizona. We will work with the State of Arizona and the USGS in applying our techniques to the search for water near Flagstaff. As part of this task we will entertain select proposals from outside investigators for the analysis of ERTS and Skylab data for regions in Western U.S. Scope will be limited to problems related to regional structures, tectonism, mineralization, ground water hydrology, land from analysis, and land use. These tasks will be supported by the digital image processing capabilities already present in the JPL Image Processing Laboratory, augmented by new analysis software as appropriate. Ground truth information will be obtained by direct observation and by use of the backpack spectrometer.

W74-70497 **177-32-11**
Ames Research Center, Moffett Field, Calif.
REMOTE SENSING DATA MANAGEMENT AND INTERPRETATION TECHNIQUES FOR EARTH RESOURCES SURVEYS
Glen Goodwin 415-965-5065

The objectives are to develop digital processing algorithms directed to the interactive enhancement of multispectral data, and to use these techniques for remote sensing applications. Grey scale mapping is used to take advantage of the eye's ability to distinguish a large number of color hues while compressing the intensity range to a scale which the eye can handle. The statistics of the intensity values are maintained.

W74-70498 **177-32-61**
Wallops Station, Wallops Island, Va.
INTERPRETATION TECHNIQUES
H. E. Maurer 703-824-3411

A remote terminal to Purdue/LARS will be used to focus the transfer of the latest in remote sensed multispectral automated data processing technology to Wallops Station and its regional users. This terminal together with other Wallops facilities, e.g., a scanning digital microdensitometer and the HON 625 computer system will be used to train Wallops data analysts and at least three regional users, to evaluate automated multispectral data processing technology prior to its implementation on Wallops or regional users computer systems and to develop an in-depth user/data techniques interface with at least one Virginia resource manager.

W74-70499 **177-32-71**
Marshall Space Flight Center, Huntsville, Ala.
REMOTE SENSING DATA MANAGEMENT AND INTERPRETATION TECHNIQUES FOR EARTH RESOURCES SURVEY
C. W. Messer 205-453-1619
(160-75-07; 160-75-34; 160-75-30; 160-75-10; 160-75-98; 160-75-86)

This effort is directed to the development of more refined techniques and conceptual/mathematical models for the processing, display, and management of large amounts of earth resources data. Results of this effort will provide essential support to those discipline-oriented projects involving land-use, hydrology, geology, vegetation resources, etc. that ultimately depend on automated data management techniques for timely earth resources planning and decision making. In general, this work will include the investigation of Earth Resources Data Analysis techniques; the development of automated data analysis systems (including a hybrid digital/optical processor for analyzing traffic patterns), the research of user needs to determine information and format requirements, and the distribution of information to users for specific application demonstrations.

W74-70500 **177-42-21**
Lewis Research Center, Cleveland, Ohio.
REMOTE SENSING DATA MANAGEMENT AND INTERPRETATION TECHNIQUES FOR EARTH RESOURCES SURVEY
Herman Mark 216-433-4000

The objectives are the development of data acquisition, handling, processing, display and management techniques, and conceptual/mathematical models essential for translation of remote sensing data into information suitable for decision by resource managers. The area of interest includes vegetation stress damage correlation with causative agents, automated recognition and inventory of surface mining operations, automated ice classification, and mapping. To achieve these goals selected sample spectral signatures will be obtained and examined in the laboratory, and compared with field measurements to determine differences and develop interpretation capability required for a real system development. In the ice studies pattern recognition computer programs are being developed to add to spectral data for practical ice classification.

W74-70501 **177-42-41**
Goddard Space Flight Center, Greenbelt, Md.
INFORMATION EXTRACTION TECHNIQUE DEVELOPMENT
W. L. Alford 301-982-5515

Automated information extraction from multispectral sensor data has proven to be a powerful tool in the management of earth resources data. Examples of such systems are the LARS (Purdue University) and the SPARC (formerly University of Michigan). Many ERTS and Skylab investigators could benefit from the use of automated image analysis techniques, but do not have access to the existing facilities and cannot justify the implementation of new systems for economic reasons. A Purdue/LARS remote terminal has been implemented at GSFC for use by in-house investigators to provide classification capability and training. It is proposed to continue the operation of the terminal and to evaluate the effectiveness of this approach. It is proposed to procure a low cost hardware multispectral image analysis system, connected to the Image Manipulation and Display System (IDAMS) and to test it with a full range of investigator analysis problems. The effectiveness of this approach vs. all-software approach will be evaluated by GSFC investigators. An additional multispectral analysis system will thus be made available to the investigator community. Both systems will be used in support of many 177-75 RTOP tasks.

W74-70502 **177-42-81**
Lyndon B. Johnson Space Center, Houston, Tex.
DEVELOPMENT OF MATHEMATICAL TECHNIQUES FOR THE ANALYSIS OF REMOTE SENSING DATA
Kenneth Baker 713-483-2362

The primary objective is to develop the mathematical techniques that are needed to analyze remote sensing data. Research will be conducted in areas of mathematics such as statistics, matric theory, and numerical analysis with the aim of improving analysis procedures until they meet the performance levels and cost constraints that are necessary for a major application of remote sensing. The research will be conducted by local universities on a task by task basis as problem areas in the analysis of remote sensing data are identified. The second objective is the development of a source of continuing education for JSC personnel in the areas of mathematics that are basic to the analysis of remote sensing data, such as statistical pattern recognition. This will be accomplished through seminars, personal consultation, etc.

W74-70503 **177-42-82**
Lyndon B. Johnson Space Center, Houston, Tex.
TECHNIQUES DEVELOPMENT FOR MULTISPECTRAL SCANNER IMAGERY
A. E. Potter 713-483-2071

Imagery multispectral scanner is potentially one of the most useful earth survey tools. To realize the full benefits of this sensor, improved methods for collecting and using the imagery are needed. The work can be classified in categories of improved data acquisition, data correction, and data analysis. Research in data acquisition will be conducted by a study of the utility of polarization and biangular signatures for discrimination. Data correction tasks involve corrections for atmospheric and geometric distortion. Data analyses research will be performed on multielement and adaptive processing and discrimination by ratioing of bands. As a necessary preliminary to an operational system, assessment of state-of-the-art technology for crop identification over large areas will be performed using existing techniques.

W74-70504 **177-42-83**
Lyndon B. Johnson Space Center, Houston, Tex.
APPLICATIONS RESEARCH AND TECHNIQUES DEVELOPMENT FOR REMOTE SENSING
A. E. Potter 713-483-2071

The overall objective is the development of applications for remote sensing technology, verification of existing techniques against these applications, and the development of new techniques to satisfy major applications requirements. Existing remote sensing technology will be exercised against a category of applications requirements carefully selected for their importance and feasibility of being satisfied by current analysis techniques. These applications requirements will be chosen on the basis of a careful analysis of the needs of agricultural applications objectives. Existing techniques in data preprocessing, clustering, feature selection, classification, data registration, multitemporal analysis, etc., will be exercised against these applications requirements and their performance will be fully evaluated.

W74-70505 **177-43-11**
Ames Research Center, Moffett Field, Calif.
REMOTE SENSING SENSOR TECHNOLOGY FOR EARTH RESOURCES SURVEYS
Glen Goodwin 415-965-5065

The objectives are to study the reflection and polarization parameters of natural materials and the atmosphere to determine how to optimize the information content in remotely sensed data and to minimize the effects of a turbid atmosphere. The approaches are: (1) derivation of both empirical parameters and physical parameters for representing the reflection properties of natural surfaces, (2) measurement of polarization parameters and display in terms of intensity, saturation and hue on a color TV system, and (3) measurement of skylight polarization and aerosols.

W74-70506 **177-43-81**
Lyndon B. Johnson Space Center, Houston, Tex.
IMAGE DATA CORRELATION AND REGISTRATION
A. W. Patterson 713-483-3373

The objective is to develop the capability for coarse registration and fine correlation of digital data from a variety of sensors for the purposes of generating accurate positional and area measurements and producing merged tapes of temporally separated data. An existing program for triangulation of panoramic photographs will be modified to coarse-register line scanner data. Fine correlation will be achieved through continued development of LEC techniques and the implementation of applicable ERIM and CDC techniques. A general solution to the coarse registration to fine correlation transition will be determined and needed algorithms will be developed.

W74-70507 **177-44-51**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
MICROWAVE GEOTHERMAL EXPLORATION
Donald P. Burcham 213-354-3028

JPL, in conjunction with the University of Nevada, will conduct scientific and technical research and perform experimental programs for furthering the applications of passive microwave techniques to the remote sensing of earth resources. Specifically, the studies will be made of near-surface characteristics of known geothermal areas studied at depth, and the extent to which the microwave signatures at longer wavelengths are related to these characteristics will be determined. Several representative geotherms will be chosen for study based upon existing data and logistic considerations. Geological studies will be conducted including determination of near-surface parameters, generation of near-surface isothermal maps, and correlation of near-surface data with existing down-hole information. Microwave studies will be performed at 21 cm wavelength on isolated controlling parameters such as penetration depth, moisture content, and salt content, and microwave isothermal maps will be generated for each geotherm. The microwave and geologic maps will be correlated and the potential of the application defined. The studies will also be conducted at wavelengths longer than 21 cm if inexpensive modification of the existing 21 cm radiometer proves feasible.

W74-70508 **177-44-82**
Lyndon B. Johnson Space Center, Houston, Tex.
RADAR STUDIES FOR EARTH OBSERVATIONS
A. E. Potter 713-483-2071

The objectives are: (1) the development of improved methods of interpreting microwave data for target parameters such as soil moisture and surface roughness, and terrain morphology; and (2) the evaluation of geological parameters that can be interpreted from existing high-resolution U. of Michigan radar data in two areas. Analysis of microwave backscattering data covering the full range of practical radar frequencies will determine the relationship of moisture and surface roughness as functions of frequency, polarization, and look angle. Existing Michigan radar data of Pisgah Crater and Mono Craters areas, California, will be evaluated and compared with interpretation of radar coverage of those areas at other frequencies.

W74-70509 **177-51-12**
Ames Research Center, Moffett Field, Calif.
REMOTE SENSING OF CROP AND RANGELAND VIGOR AND TIMBER STAND TO PREDICT YIELD
Glen Goodwin 415-965-5065
(160-75-21; 160-75-15; 160-75-13; 160-75-19)

The objective is to develop remote sensing techniques for determination of crop and rangeland vigor for the use of resource managers in assessing state of and change in domestic wildland vegetation. Imagery from high flight, ERTS and EREP will be treated to determine methods of most efficient use in assessing and predicting wildland yield. Automatic classification programs, mapping procedures, interpretation techniques and information transfer mechanisms will be developed for user resource agencies. Cost/benefit ratios will be optimized with the cooperation of user resource agencies. Coverage will be expanded to apply to a variety of wildland resource inventory needs, of the state and country. The studies elaborated here will constitute candidate requirements for operational mode in ERTS 1 and B, and the Low Earth Orbit Geosynchronous satellites planned for the late 70's and 80's.

W74-70510 **177-51-61**
Wallops Station, Wallops Island, Va.
REMOTE SENSING OF VEGETATION FOR INVENTORY AND MONITORING
J. H. Scott 703-824-4311
(160-75-21; 160-75-17)

This project is designed to apply remote sensing and advanced technology to the agricultural and forestry problems in the Chesapeake Bay area. Climatological data and soil conditions will be related to the vigor of major crops under both normal and stressed situations using multispectral remote sensing techniques in combination with ground truth data obtained by trained observers. Synoptic identification of crops will be accomplished by establishing multispectral signatures. Local resource management problems will be identified and data will be made available where an evaluation determines its expediency. A large data base has been collected within the confines of the Chesapeake Bay Region by utilizing a combination of ground instrumentation and trained observers and multispectral remote sensing techniques. This data base covers regional development of crops over two complete growing seasons and will now be applied to areas of unknown quantities to develop multispectral signatures. Part of this work will be the assessment of environmental conditions that relate to susceptibility and control of stress in forested regions. Passive remote sensing systems, such as multispectral imagery from aircraft and spacecraft, and active systems such as side-looking radar and lasers will be basic tools in the collection of data.

W74-70511 **177-51-71**
Marshall Space Flight Center, Huntsville, Ala.
REMOTE SENSING OF VEGETATION AND WILDLAND RESOURCE STRESSES
J. C. Derington 205-453-2143
(160-75-07; 160-75-30; 160-75-99)

The primary objective of this work is the application of existing aerospace techniques to local or regional problems of concern

to federal, state, and county decision makers and other groups in the regional user community. A secondary objective is to introduce user groups to the potential value of ERTS and Skylab Earth Resources data for agricultural and forestry purposes and to encourage them to plan the use of such data as it becomes available in the future. To accomplish the above, certain projects are proposed to demonstrate the application of existing remote sensing techniques to the detection of stress in crops and forests of this region. User-partners have been chosen, including the Auburn University Cooperative Extension Service, the University of Georgia Experiment Stations, and the U.S.D.A. Research Station, to provide representative variety in crops and test sites for the Southeastern region. Test sites will be identified for the crops and forests at various locations in Georgia and Alabama by the Extension Service and Experiment Station personnel. The primary test site (Task 01) will be the Auburn Experimental Stations in Alabama. MSFC will provide aircraft overflights of the selected sites at the proper time in the growth cycle to gather multispectral photographic data, and possible infrared scanner data, of crops under insect or nutrient stress and also of healthy crops. Detailed study and analysis of the remotely sensed data and its correlation to ground truth data will be done, for the most part, by the Extension Service and Experiment Station personnel, and automatic interpretation techniques will be investigated. Determinations will be made as to the effectiveness of such data in determining plant stress in this region, and the potential for scaling up to the use of satellite data for this purpose. University and county Extension Service personnel will cooperate to develop techniques for utilization and dissemination of the results to the user community. The proposed projects are continuations of demonstration projects begun in FY-72.

W74-70512 **177-51-82**
Lyndon B. Johnson Space Center, Houston, Tex.
ASCS PROJECT
R. Bryan Erb 713-483-4623

The objective of the ASCS Project is to work jointly with the USDA-ASCS to evaluate the utility of ERTS 1 data to fulfill the functional requirements of crop identification, field measurement, and correlation to specific tracts. The data utilization will consist of an appraisal of computerized and conventional image interpretation data processing techniques. In order to meet the objectives of the evaluation, it will be phased in complexity. Six study areas from 18 counties throughout the U.S. have been selected by the ASCS for intensive study. The order of appraising the county study areas will be developed to allow a progression from an area of large regular shape with low crop complexity, through areas of medium sized fields and medium crop complexity, to an area of small fields of irregular shape and a relatively high degree of crop complexity. During the course of the evaluation several techniques will be explored and utilized. These techniques include computerized analysis, image enhancement, conventional image interpretation, and temporal analysis.

W74-70513 **177-51-83**
Lyndon B. Johnson Space Center, Houston, Tex.
FEASIBILITY FOR REMOTE SENSING OF STRESSED CROPS
A. E. Potter 713-483-2071

Remote sensing of stressed crops will be important for accurate crop productivity estimations. Little is known about the feasibility for sensing disease and water deficiency stress by multispectral scanners. This task is concerned with determining the capability of multispectral scanners for remote sensing of virus and water deficiency stress on wheat and sorghum. The approach is to measure reflectance spectra of wheat and sorghum fields at biweekly intervals as the stress develops. Cluster analysis of the spectra is used to determine how soon the stress can be detected, and what spectral bands are best for detecting it. Two parallel efforts are planned: one is at Texas A&M, where the JSC field spectrometer is used to collect spectra; the other is near Lubbock, Texas, where ERTS is used to collect spectra.

W74-70514 **177-51-84**
Lyndon B. Johnson Space Center, Houston, Tex.
JOINT EXPERIMENT ON REMOTE SENSING OF SOIL MOISTURE
A. E. Potter 713-483-2071

Remote sensing of soil moisture by microwave techniques, (either radar or passive microwave) is a possibility, since soil moisture greatly affects radar cross section and microwave emissivity. The degree to which this possibility can be realized into a practical technique is not known. The problem is complex, requiring simultaneous attack by hardware groups, analysis groups, soils experts, etc. The objective of this task is to organize and execute an attack on the problem in a joint effort, including all the required elements, drawn from several different organizations. A site will be chosen, preliminary ground-based measurements made, and a flight experiment will be performed. Analysis of data from the flight experiment is expected to yield an estimate of the feasibility and uncover unpredicted problems for remote sensing of soil moisture. Groups from ERIM, Texas A&M, and University of Kansas will be involved actively. Consultants from USDA (Weslaco) will also be involved.

W74-70515 **177-51-91**
John F. Kennedy Space Center, Cocoa Beach, Fla.
AGRICULTURAL RESEARCH
J. P. Claybourne 305-867-6132

The purpose is to establish a cost-effective and near real-time method using remote sensing techniques combined with automatic data processing and math modeling to determine the edaphic, topographic, hydrologic, agronomic, and climatological response characterization and parameter estimation for Florida citrus and croplands. A specific technical approach has not been decided upon. Selection of a performing organization will be based in part on the technical approach proposed.

W74-70516 **177-52-11**
Ames Research Center, Moffett Field, Calif.
REMOTE SENSING FOR THEMATIC MAPPING OF CULTURAL, NATURAL AND PHYSICAL PATTERNS AND CHANGES
Glen Goodwin 415-965-5065

The objective is to apply remote sensing technology to land use parameters for use by California coastal regional planners. The approaches are: (1) to formulate a comprehensive image adaptable classification scheme identifying significant environmental parameters for which data needs to be collected; (2) to map and test the classification system for a few areas; (3) to digitize boundaries and characteristics in a format which can be stored, manipulated and displayed by computer; and (4) to disseminate results through training programs for the users. Emphasis will be given to the use of ERTS 1 and EREP data and consideration will be given to operational requirements for applications of ERTS-B and low earth orbit satellites of the late 70's.

W74-70517 **177-52-12**
Ames Research Center, Moffett Field, Calif.
DEMONSTRATION PROJECT EVALUATION
Glen Goodwin 415-965-5065
(160-75-30; 160-75-98; 160-75-15; 160-75-63)

The objective is to evaluate potential demonstration projects with user agencies in areas of environmental quality, land use and lake eutrophication. A systems engineering approach will be used in evaluating the feasibility of mounting a demonstration project of one of three candidate studies. Interdisciplinary teams will be organized to examine the potential of a Lake Tahoe environmental surveillance system, A San Francisco Bay area land use mapping and monitoring system, or a comprehensive system of monitoring and managing lake eutrophication processes. Favorable cost/benefit ratios will be considered determinative factors in evaluation as will be applicable NASA-unique capabilities, particularly in remote sensing and communications technology. A strong user need and involvement, already identified, will be an overriding prerequisite, with the stated intent of preparing the user for ultimate system management. Each of the three demonstration candidates would make use of the ERTS-1 and ERTS B satellites in the NASA Earth Observations Mission Model. The imagery, and in some cases the Data Collection System, would be incorporated with the project.

W74-70518 **177-52-13**
Ames Research Center, Moffett Field, Calif.
USER COMMUNICATIONS
Glen Goodwin 415-965-5065
(160-75-63; 160-75-86)

The objectives are: (1) to provide methods of involving users in the remote sensing data gathering system--high flight and satellite program/principal investigator studies/resource management; and (2) to efficiently guide basic studies in the way of user utility. Information transfer mechanisms will be studied as they best apply to identifying user needs of remote sensing data and to methods of involving resource management in the operational requirements of such data. Resource agencies and farm organizations will be considered as they interact, or do not, in their informed requirements for remote sensing. Basic studies in remote sensing will be oriented where feasible to specific resource agency needs. Efforts of the various laboratories will be coordinated to achieve this end as well as to ensure efficient, nonredundancy of work.

W74-70519 **177-52-14**
Ames Research Center, Moffett Field, Calif.
CALIFORNIA REGIONAL APPLICATIONS PROGRAM
Glen Goodwin 415-965-5065
(160-75-15; 160-75-11; 160-75-63)

The objectives are: coordination of various California regional applications of NASA technology including ERTS and EREP studies monitoring; development of techniques for use of A/C- and S/C-acquired data for user agencies; and response of Center-unique capability to statutory needs of users. In order to effect an efficient exploitation of unique NASA and Center technology by regional resource managers, the Earth Science Applications Office (Code SE) has been organized to coordinate applications activities within the center and with user requirements. Effective liaison has been established with California resources agencies directly and through the State Coordinator of Remote Sensing. Workshops have been and will be conducted to apprise users of applicable space technology. In monitoring EREP and ERTS contracts, and the University of California grant for remote sensing studies, PIs will be encouraged to stress State and regional user benefits. Ames A/C support of remote sensing technology development will be coordinated, where feasible, with regional user requirements as will other Ames in-house applications investigations. These latter studies relate directly to need of various State agencies; e.g., OES, WCB, Forestry, Agriculture, Highways, Communications. The Regional Applications would make use of the ERTS 1 and ERTS-B satellites in the NASA Earth Observations Mission Model. Both imagery, and in some instances the Data Collection System, would be a part of the program.

W74-70520 **177-52-41**
Goddard Space Flight Center, Greenbelt, Md.
GENERATION OF INTEGRATED THEMATIC DATA BASE AND DEMONSTRATION OF ITS USE IN REGIONAL ENVIRONMENT/LAND USE MANAGEMENT
Louis Walter 301-982-4671
(160-75-98)

The objectives are to integrate remotely-sensed and other data pertinent to environmental/land use problems in a limited test area; to identify, in that area, the disparate users on the operational level; and to define technical data products which can most readily and advantageously be applied by operational level users having similar needs in other regions. At the center of this effort is a task for a land use-environmental study which will have, as its purpose: (1) the integration of the data produced in the several tasks of the study; (2) the development of a base (in map and computerized form) of regional land use information; (3) the identification and stimulation of a local user community; (4) the dissemination of data in a form in which it can readily be applied by the users; (5) the assessment of the efficacy of the regional survey, especially in comparison with alternative methods; and (6) the consideration of system modifications required for greater utility and efficiency. The objectives of the the subsidiary tasks are to provide bases for the central study in geology, hydrology and computer sciences; to explore, in greater detail, the important environmental problems of silt-, and radionuclear-pollution and their sources in this geographic area.

W74-70521 **177-52-61**
Wallops Station, Wallops Island, Va.
REMOTE SENSING FOR MULTIRESOURCE SURVEYS IN THE CHESAPEAKE BAY REGION
P. J. Alfonsi 703-824-3411

NASA Wallops Station will continue to cooperate with local, state, and federal agencies and academic institutions in Regional Multiresource Survey programs which identify, demonstrate and evaluate specific practical applications of remote sensing from aircraft and spacecraft. The emphasis of the effort will be in the utilization of active sensors for regional multiresource surveys. There are two major objectives outlined in this plan. The first involves operational supporting services for Wallops RTOPs which have been submitted to the Applications Office. This operational support includes, in addition to sensor development and data acquisition, data storage and management activities necessary to satisfy the Sioux Falls EROS Data Center archival requirements. The second major objective is the continuation of a limited program of non-funded cooperative multiresource surveys pertaining to specific problems of concern to regional resource managers. The emphasis in the non-funded efforts will be directed toward investigations which appear to have relatively short range highly visable results. Information obtained from all Wallops Station Multiresource Survey Operations will continue to be deposited into a regional information center which will provide baseline data to aid in the development of techniques for the understanding and management of long range natural resource problems.

W74-70522 **177-52-71**
Marshall Space Flight Center, Huntsville, Ala.
LAND-USE MAPPING FOR RESOURCE MANAGEMENT
C. T. Paludan 205-453-2142
(160-75-30)

The objective is to complete development and demonstration of techniques for deriving and disseminating land-use information. Sub-objectives include: (1) understanding of user needs, (2) use of aircraft, ERTS, and Skylab data sources, (3) decisions on classification system, locational grid, format, and scale, (4) decisions on data processing methodology based experimental demonstrations, and (5) decisions on information retrieval and presentation modes, including computer interactive systems, maps, and information overlay methods. The objective requires a group of user-NASA partnerships with state, regional, national, and international planning organizations. This research may be divided into four areas: (1) user partnerships, (2) liaison and decisions on classification, locational grid, format, and scale, (3) development of automatic classification methodologies and decision on optimum, and (4) research and demonstration of information retrieval and presentation systems. Data from aircraft multispectral imagery, ERTS 1, and Skylab will be the basis for research.

W74-70523 **177-52-72**
Marshall Space Flight Center, Huntsville, Ala.
REMOTE SENSING FOR URBAN GEOGRAPHY
C. T. Paludan 205-453-2142
(160-75-07; 160-75-34)

The objective is to define the utility of small scale remotely sensed data to investigations of urban environmental problems. Limitations imposed by scale and resolution will be investigated in order to determine if realistic information can be expected for certain specified problem areas. Specific areas investigated include: (1) information for the Community Renewal Program, (2) transportation studies, (3) urban land-use, and (4) the urban-rural contrast. A study of the utility of remote sensing for determination of urban environmental quality, especially as required by the Community Renewal Program, will be completed by August 30, 1973 by the University of Denver under Contract NAS8-28216. During the Summer of 1973 this activity will be phased over to an emerging institution in Louisiana. Transportation studies are in process under RTOP 160-75-34. Although emphasis of RTOP 160-75-07 is on non-urban land-use, it is expected

that crude urban land-use information will result, especially in the important urban fringe. It is proposed that a new task, the study of urban-rural contrasts, be initiated in the Summer of 1974.

W74-70524 **177-52-73**
Marshall Space Flight Center, Huntsville, Ala.
MULTIPLE RESOURCE SURVEYS/REGIONAL ACTIVITIES
C. T. Paludan 205-453-2142
(160-75-07; 160-75-14; 160-75-98)

The objective is to develop methods of using remote sensing and automatic data handling for, delineation and description of resources, with emphasis on cooperative activities with state and regional planning and development organizations. Because they are basic to comprehensive understanding and management of multiple resources, emphasis is on land-use and water resources. Formal (contractual) and informal (exchanges of correspondence) partnerships have been established under this objective with a number of planning, development and research organizations--all in the Tennessee Valley area. Partnership organizations include: Tennessee Valley Authority, Tennessee State Planning Office, Alabama Development Office, Tennessee-Tombigbee Waterway Authority, Top of Alabama Regional Council of Governments, North Central Ala. Regional Council of Governments, University of Alabama in Huntsville, and International Business Machines Corp. Operations of the Tennessee Valley Authority (TVA) provide the key emphasis of this research. Studies of the Tennessee River near the Brown's Ferry nuclear power plant are conducted to establish a data base prior to activation. These include in situ and remote sensing studies of aquatic life and water quality in cooperation with the University of Alabama in Huntsville. Land-use mapping, using techniques developed under RTOP 160-75-07, will be completed of an EREP test site in Northeast Alabama in cooperation with TVA, and in Northeast Mississippi in cooperation with the Tennessee-Tombigbee Waterway Authority and Mississippi State University.

W74-70525 **177-52-74**
Marshall Space Flight Center, Huntsville, Ala.
MAJOR APPLICATIONS DEMONSTRATIONS
G. F. McDonough 205-453-2880
(160-75-86; 160-75-98; 160-75-99)

In consonance with OA guidelines and in response to JSC Earth Resources Lead Center request, MSFC has accepted responsibility for continuing a cooperative hydrology experiment with the Corps of Engineers. The research will explore the application of remote sensing, automatic data processing, modeling and other aerospace technology to hydrological engineering and water resource management. The project, begun with Galveston Bay as a test site, will be conducted using Mobile Bay and its estuaries as a new test site more accessible to MSFC and the Corps' Vicksburg, Mississippi operations. Mobile Bay also is part of a current ERTS and planned EREP test site and will close the loop on MSFC major hydrological/water resource emphasis programs which include the entire river drainage system which feeds the Mobile Bay and the future impact area, the Tennessee-Tombigbee Canal, a project which will connect the Tennessee-Ohio River Systems to Mobile Bay via the Alabama-Tombigbee Rivers. Resource support from OA SRT is required for MSFC participation in this project since there are no other funds currently available. The limited funding requested here is justified by the national application potential alone since Corps of Engineers has nation-wide responsibility for the functions being investigated and will find beneficial applications throughout their operation. A second research experiment which is planned by the user as a potential major demonstration of space technology application is traffic/transportation management using remote sensing and optical/digital data processing as the prime elements of current management/planning tools, i.e. traffic models.

W74-70526 **177-52-75**
Marshall Space Flight Center, Huntsville, Ala.
REMOTE SENSING: NATIONAL PARK AREAS, RECREATIONAL AND ARCHEOLOGICAL SITES
J. L. Daniels 205-453-0889
(160-75-06; 160-75-07; 160-75-08; 160-75-14; 160-75-30; 160-75-98)

The objective is to determine the extent to which remote sensing from aircraft and satellite can assist planning and development agencies in locating and identifying historical, archeological, or prospective recreational park areas in vegetated land in planned water improvement areas. Existing records, surveys and other ground truth available from professional and discipline experts, i.e. archeologists, historians, environmentalists, parks and recreation planners will be used as basic information sources. This information will be compared with imagery from medium level multispectral photography, scanner data, and EREP imagery to ascertain applicable remote sensing roles in this type activity. Comprehensive information for planners in these fields is difficult to obtain by conventional field methods. However a number of indicators such as terrain features, land forms, vegetation and soil characteristics, and other parameters are discernable on medium-scale multispectral and infrared photography and may be provided by ERTS and EREP imagery. Current and past investigations in the ERTS program and in other remote sensing studies have shown promise and indicated the feasibility of applications in these areas.

W74-70527 **177-52-81**
Mississippi Test Facility, Bay Saint Louis.
LAND USE AND RESOURCE INVENTORY
R. O. Piland 601-688-2034

The objectives are to: (1) conduct research investigations in the Mississippi/Louisiana areas in land use classification applications of remote sensing, stressing the interests and needs of agencies in the area; (2) extend these research investigations into experimental demonstration projects in cooperation with local agencies where appropriate; (3) utilize existing aircraft and satellite programs as a primary source of remote sensing data, and collect and analyze surface data for correlation with these flight data; and (4) conduct continuing studies of user requirements of the potential land use classifications in order to guide future research efforts. Land use-resource inventory projects planned for FY-74 fall into three major categories and their subdivisions as follows: (1) state-wide land use system applications (small-scale photographic application, ERTS MSS imagery application, and ERTS MSS digital application); (2) technique development (agricultural and forestry); and (3) special applications and selected area applications.

W74-70528 **177-52-82**
Lyndon B. Johnson Space Center, Houston, Tex.
LAND USE: TEXAS DEMONSTRATION PROJECTS
R. Bryan Erb 713-483-4623

The State of Texas is presently establishing better planning and coordination in all aspects of state governmental activities. New dimensions in state and local governmental relations have evolved in the establishment of Regional Council of Government throughout the state with specific needs for regional planning and management information. The Governor has formed the Inter Agency Council on Natural Resources and the Environment to ensure a well coordinated focus on all aspects of land use planning, natural resources and environmental assessments. The Governor has directed the Division of Planning Coordination (DPC) and the Office of Information Services (OIS) to work with the Inter Agency Council to develop a Natural Resources Information System (NRIS) to meet the information needs. NASA has been contacted by the Governor's Office to explorer a cooperative program to transfer remote sensing and information systems technology to the state. A Texas demonstration project is being planned, with the objective to design, develop and demonstrate a pilot model of an operational system for the collection, processing, analysis, storage and retrieval, and dissemination of land use information and related natural resource and environmental information for the State of Texas.

W74-70529 **176-53-12**
Ames Research Center, Moffett Field, Calif.
DEMONSTRATION PROJECT EVALUATION
Glen Goodwin 415-965-5065
(160-75-30; 160-75-98; 160-75-15; 160-75-63)

The objective to evaluate potential demonstration projects

with user agencies in areas of environmental quality, land use, and lake eutrophication. A systems engineering approach will be used in evaluating the feasibility of mounting a demonstration project on one of three candidate studies. Interdisciplinary teams will be organized to examine the potential of Lake Tahoe environmental surveillance system, a San Francisco Bay Area land use mapping and monitoring system, or a comprehensive system of monitoring and managing lake eutrophication processes. Favorable cost/benefit ratios will be considered determinative factors in evaluation as will be applicable NASA-unique capabilities, particularly in remote sensing and communications technology. A strong user need and involvement, already identified, will be an overriding prerequisite, with the stated intent of preparing the user for ultimate system management. Each of the three demonstration candidates would make use of the ERTS-1 and ERTS-B satellites in the NASA Earth Observations Mission Model. The imagery, and in some cases the data collection system, would be incorporated with the project.

W74-70530 **177-53-11**
Ames Research Center, Moffett Field, Calif.
REMOTE SENSING FOR GEOLOGIC HAZARDS AND DISASTERS, MINE AREA CONSERVATION, SOIL MAPPING AND LAND USE PLANNING
Glen Goodwin 415-965-5065

The objectives are: (1) to analyze landslides and other geologic structures prone to mass movement using an infrared radiation imaging system, and (2) to help solve specific problems of several State of California agencies by obtaining infrared imagery of water and land features, and assisting in image interpretation. Large scale imagery is required for detailed analysis and correlation with carefully completed field studies. To determine those factors that influence soil and water surface temperatures, low altitude flights on a diurnal and seasonal basis using an infrared line scanner will be made. ERTS 1 imagery will be used along with CV-990 and U-2 underflight missions. ERTS-B thermal imagery will be used when available.

W74-70531 **177-53-71**
Marshall Space Flight Center, Huntsville, Ala.
REMOTE SENSING FOR GEOLOGICAL RESOURCE SURVEY
J. Bensko 205-453-0187
(160-75-14; 160-75-15; 160-75-07; 160-75-98; 160-75-99)

The objective is: to investigate the applicability of remote sensing and other space technology to the problems of Federal and State agencies with planning or other direct responsibilities for producing decision-base information necessary for effective resources management in the areas of environmental geology, engineering geology, mineralogy, geobotany, and geothermal technology. Selected State and Federal user-partner agencies together with MSFC technical personnel will define basic problems and will develop a project plan for alternate solutions. The plans will include: (1) acquisition of remote sensing data, processing (testing automated techniques, and systems engineering by MSFC; and (2) discipline expertise, data analysis, information interpretation and application by the user agencies.

W74-70532 **177-54-11**
Ames Research Center, Moffett Field, Calif.
REMOTE SENSING FOR SNOW AND ICE MAPPING AND MONITORING
Glen Goodwin 415-965-5065

Snowpack will be evaluated by use of remote sensor technology, leading to hydrological cycle data input, so as to achieve better utilization of water resources, flood forecasting, and related activities. Remote sensing technique will be applied for the measurement of the extent, depth, density, and percent moisture of snowpack, to assist in water resource management. Specific techniques include high-resolution photography and associated interpretation (including vegetation and forestry terrain) in order to obtain areal snow coverage; multifrequency electromagnetic sounding for measurement of snowpack depth and density; and attenuation of electromagnetic waves by free-water present in a melting snowpack. Ground-truth data will be established by use of standard snow sampling tubes for depth and density. Areal extent will be established by snow surveys in selected regions, for example the Feature River watershed. Percent free water will be obtained by measurement of the change in dielectric constant of snow sample when it state is changed from the melting condition to completely frozen (about 5 C). In addition to comparison with ground-truth, the remote sensing measurements will be compared to run-off measurements obtained by other government agencies. ERTS-1 and and EREP data will be used in these studies.

W74-70533 **177-54-12**
Ames Research Center, Moffett Field, Calif.
INVESTIGATIONS OF THE HYDROLOGICAL CYCLE AND LARGE SCALE HYDROLOGIC SYSTEMS
Glen Goodwin 415-965-5065
(160-75-63; 160-75-86)

The objective is to apply remote sensing technology to the measurement of hydrologic cycle parameters for better utilization of water resources. Remote sensing techniques will be applied to the study of hydrological parameters related to water resource management, with particular regard to the California Water Project and inland water quality measurements. Specific watershed areas will be defined in terms of run-off characteristics, vegetation type, catchment, quality problems, etc. Water resource planners will be consulted for their needs and educated in the use of remotely sensed data. Emphasis will be given to the use of ERTS 1 and EREP data and consideration will be given to operational requirements for applications of ERTS-B and the Low Earth Orbit Geosynchronous satellites planned for the late 70's and 80's.

W74-70534 **177-54-13**
Ames Research Center, Moffett Field, Calif.
REMOTE SENSING OF SURFACE FRESH WATER (RIVER AND LAKE) AND GROUND WATER RESOURCES AND PROCESSES
Glen Goodwin 415-965-5065

The objective is to correlate river meander patterns and discharge rates and to validate the technique on a statistical basis. The approaches are: (1) to digitize the stream meander pattern over successive frames of imagery to obtain a stream meander pattern which is long compared to the wavelength of the meander spectrum, and (2) to correlate the wavelength spectrum with discharge using many rivers on a statistical basis.

W74-70535 **177-54-21**
Lewis Research Center, Cleveland, Ohio.
REMOTE SENSING FOR SNOW AND ICE MAPPING AND MONITORING
Herman Mark 216-433-6201

The primary objective is to develop a rapid all-weather ice information system for determining ice type and coverage on the Great Lakes for navigation purposes. A criterion for the system is that it provides the necessary information in a form that can be used in the wheelhouse for transiting the ice with minimum difficulty. This effort is being performed as part of the 'Winter Navigation Season Extension Program' authorized by Congress in 1970. During the 1972-1973 and 1973-1974 winters, an AN/APS-94C Side Looking Airborne Radar (SLAP) will be frequently flown over Lake Erie and the adjacent Great Lakes to obtain radar imagery of the ice cover. Visual and automatic methods will be developed for interpreting this imagery for ice type, distribution, thickness, and motion. As an aid for developing these interpretive methods extensive ground truth and low-altitude visual and thermal imagery will be acquired. Once the aircraft ice information system is developed it will be turned over to the U.S. Coast Guard. Detail studies will be performed to determine the feasibility and cost benefits of taking the ice information system to satellite altitudes.

W74-70536 **177-54-41**
Goddard Space Flight Center, Greenbelt, Md.
INVESTIGATIONS FOR THE HYDROLOGICAL CYCLE AND LARGE HYDROLOGICAL SYSTEMS
Vincent V. Salomonson 301-982-6481
(160-75-30; 160-75-63; 160-75-14; 160-75-31; 160-75-99)

The objective is to perform studies and analyses which (1) quantitatively and objectively define the temporal and spatial accuracies and frequencies in spacecraft sensor systems needed to optimally monitor the various phases of the hydrological cycle and watershed features covering large geographical regions and (2) assess the size of the data reduction, analysis, and distribution tasks commensurate with the monitoring of hydrologic processes over large geographical regions. The most expeditious means of both assessing the optimal spatial and temporal accuracies and frequencies needed for monitoring the hydrological cycle is to use a sensitivity analysis approach applied to representative and realistic models of the hydrological cycle. Herein the sensitivity of some parameter, such as runoff, to variations in forest cover, impervious area, infiltration, or drainage basin area is ascertained. For instance, a 10-20 percent variation in forest cover may only result in a 5% variation in runoff whereas a 1-2% variation in impervious area may create a similar runoff response. During the FY-73 period tasks were initiated in which models are to be developed in which parameters are incorporated that are normally observed or can very likely be, based on current knowledge, observed by remote sensing. During FY-73 more emphasis---

W74-70537 **177-54-71**
Marshall Space Flight Center, Huntsville, Ala.
INVESTIGATIONS OF THE HYDROLOGIC CYCLE AND LARGE SCALE HYDROLOGIC SYSTEMS
H. G. Hamby 205-453-0889
(160-75-98; 160-75-10; 160-75-30; 160-75-34)

The objectives are: (1) to extend or adapt existing hydrologic models to incorporate remote sensing data for parameter determination; (2) to reduce requirements for historical rainfall/runoff/streamflow data by improved predictive capabilities using remote sensing; (3) to apply advanced modeling concepts, notably finite element techniques to make existing models more amenable to remote sensing parameter determination; (4) to improve and extend existing river and estuary mathematical models to full three-dimensional descriptions so that surface or near surface remotely sensed parameters can be utilized most efficiently to monitor streamflow, temperature profiles and other significant parameters; and (5) to develop a predictive model of a deep reservoir into which elevated-temperature discharges are made; the model will be developed to utilize remote sensing inputs. Existing models for watersheds, streams and rivers, deep lakes, and bays and estuaries will be augmented, modified and improved to incorporate remotely sensed data from aircraft and satellites as well as in situ measurements. Advanced three-dimensional modeling techniques developed for rocket exhaust plume analysis and finite element analytical techniques will be adapted to watershed and water-body analysis. Existing user expertise, in particular the Tennessee Valley Authority, U. S. Geological Survey and the U. S. Army Corps of Engineers will be utilized and all models will be shaped in partnership with these users to suit their operational requirements.---

W74-70538 **177-55-11**
Ames Research Center, Moffett Field, Calif.
REMOTE SENSING OF COASTAL UPWELLING
Glen Goodwin 415-965-5065
(160-75-98)

The objective is to apply remote (satellite and aircraft) sensing techniques to the study of coastal upwellings to obtain additional synoptic and sequential coverage required to develop adequate predictive physical and biological models of these events. Selected upwellings will be studied cooperatively with Oceanographic Institutions, the National Marine Fisheries Service and commercial fishery organizations. The upwellings will be continuously monitored via satellite thermal imagery from their inception to their terminal phases. Real time satellite thermal imagery will be interpreted on a routine basis and, during participatory phases, facsimiles of interpreted imagery will be relayed to research ships. Aircraft underflights, for chlorophyll and temperature mapping, coordinated with ship operations will be conducted to correlate remote and in situ measurements. Further underflights will be scheduled throughout the upwelling regardless of surface vessel availability to document and refine satellite imagery interpretations. Some surface data may be obtained during this mode from 'as available' commercial ships and fishing boats. Data obtained by all sources will be pooled and predictive physical and biologic models will be developed or improved. NOAA II and Project FAMOS thermal imagery is now being used. ERTS-B especially Nimbus G (1977) thermal imagery (and ocean color, etc.) will be invaluable in a continuation of this study.

W74-70539 **177-55-32**
Langley Research Center, Langley Station, Va.
COORDINATION FOR OFFICE OF APPLICATIONS PROGRAMS
Eugene S. Love 703-827-2893

The designated role of the Langley Research Center as focal center for environmental monitoring requires the coordination with Headquarters, Lead Centers, and other agencies for numerous programs of the Office of Applications. Additional related activities at Langley and other centers, such as coastal zone oceanography and locally oriented applications, require a similar response. The following tasks are included: (1) provide Headquarters and Lead Centers with technical and administrative assistance to increase the responsiveness of NASA to recurring and non-recurring activities involving assembly, organization and preparation of documentation for inclusion in programmatic reports, congressional and budget submissions; (2) participate as observers of members of various interagency committees and subcommittees and aid Headquarters as required in the preparation of material for these groups; (3) maintain an awareness of the program and requirements of user agencies that may benefit from the use of aerospace technology such as remote sensing from aircraft and spacecraft; and (4) assist in the indentification, compiling, and formulation of information concerning vessels of opportunity for surface-truth support of oceanography related projects, including both ships and aircraft.

W74-70540 **177-55-33**
Langley Research Center, Langley Station, Va.
LIVING MARINE RESOURCES
Eugene S. Love 703-827-2893
(160-75-17; 160-75-18)

The objectives are: to assist federal, state, and local agencies in developing effective methods of applying remote sensing techniques and mathematical modeling to classify, monitor, survey, and eventually manage coastal wetlands; to conduct applied research aimed at measurements within wetlands that influence living resources of estuarine ecosystems, and the multiple use of these systems for the benefit of man; and to measure and model the effects of modification of wetlands to the natural resources of the marine environment. Initially this research will develop vegetation keys from the textural photographic signatures of various wetland species as one source of remote ground-truth information for the analysis of existing and future remote sensing data. This key will be incorporated, along with other calibration techniques, to provide remotely sensed information for the user agencies to evaluate the ecological significance of wetlands, and to predict the effects of physical changes and pollution on the diversity of the biota and productivity using mathematical models. This research is in harmony with Langley's developing role in the enhancement of environmental quality, i.e. to expand our knowledge in measurement and abatement technology, so that user agencies can more effectively analyze and manage the wetland environment.

W74-70541 **177-55-34**
Langley Research Center, Langley Station, Va.
MARINE TRANSPORTATION AND COASTAL ACTIVITIES
Eugene S. Love 703-827-2893
(502-23-56)

The basic objectives of this research are to develop and apply space technology and techniques in remote sensing, tracking, electronics, and data relay to provide information for improving ship routing and for planning, managing, and monitoring coastal activities. A typical area of investigation is the utilization of laser and electronic technology to design, assemble, test and demonstrate a prototype airborne Lidar system to remotely determine bathymetry information. Such information will be useful in the

selection of sites for off-shore port facilities and coastal nuclear power plants and in the surveillance of dredged channels and coastal shore lines. Other areas of interest will be the determination of turbidity, sediment loading and currents associate with marine installations and marine transportation facilities.

W74-70542 **177-55-35**
Langley Research Center, Langley Station, Va.
PHYSICAL OCEANOGRAPHY AND COASTAL PROCESSES, INCLUDING MARINE DISASTERS
Eugene S. Love 703-827-2893

This RTOP includes work described in the 'Environmental Quality Enhancement Program Study" prepared for the Office of Applications by the Langley Research Center. Specifically, work on Task 1 (Wave Measurement and Analysis on the Continental Shelf) and Task 2 (Current Circulation Studies on the Continental Shelf) will be accomplished under this RTOP. The objective is to develop a predictive capability for the wave and current environment in Continental Shelf waters for application to problems in these waters. Problem areas of interest include pollution distribution and circulation on the shelf, sedimentation, thermal properties of shelf waters, wave climate, and shoreline alteration. Approach to be used includes the development of analytical wave and current models and the measurement of conditions on the shelf by various means to provide data for preliminary model verification, and to develop input measurement techniques for eventual use with monitoring system. Measurement methods to be used include remotely sensed data from satellites (such as NOAA II) and aircraft, and surface observations from drifting or fixed stations with location information and measured data relayed by satellite (such as EOLE) and aircraft. Overguideline funding requests for FY-74 are detailed on the individual task T-8's and in general provide improved tracking aids, earlier starts on some important applications and study economic benefits to be derived.

W74-70543 **177-55-41**
Goddard Space Flight Center, Greenbelt, Md.
REMOTE SENSING OF OCEANOGRAPHIC COLOR AND TEMPERATURE AND ICE COVER OF NAVIGABLE WATERS
W. A. Hovis 301-982-6465
(160-75-96)

The objective of this RTOP is to conduct laboratory and field experiments, with remote sensors, to determine the optimum instrumentation parameters and data reduction and analysis techniques for use on upcoming applications satellite programs. Two areas are to be stressed, utilizing the experimental capability and experience of the laboratory for Meteorology and Earth Sciences. Ocean and coastal water color will be remotely sensed utilizing a flexible, multi-channel scanner to determine what parameters are best for a particular application and how the effects of atmospheric interference can be minimized. This effort will be carried out in cooperation with NOAA, Atlantic Oceanographic and Meteorological Laboratory to assure accurate surface and atmospheric truth measurements. Ice, snow and soil moisture sensing will be carried out utilizing microwave mappers. Snow field mapping will be carried out with aircraft and Nimbus data. Ice extent and type will be measured in a quasi-operational mode over the Great Lakes to determine how shipping interests might be aided by ice cover information from all weather, night or day sensor.

W74-70544 **177-55-51**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
OCEANOGRAPHIC STUDIES (RADAR)
Donald P. Burcham 213-354-3028

The purpose of this task is to apply radar techniques to the measurement of ocean surface parameters. The work includes: (1) using the JPL radar to make observations in joint operations with NOAA, (2) performing data reduction, analysis and calibration of the radar characteristics with NOAA, (3) correlating the radar measurements with measurements from other instruments on the aircraft such as the laser wave profiler as well as measurements made from surface ships, and (4) modifying the radar (the JPL L-band radar) so that the particular parameters of interest are observed with adequate signal-to-noise ratio. A second major purpose of the work is to evolve a breadboard of a radar that is particularly suited for obtaining the pertinent oceanographic information as specified by NOAA and other users of the observations and lead towards a spacecraft mission for oceanographic observations. The approach is: (1) to use the existing JPL L-band radar in conjunction with the NOAA C-130 or the NASA CV-990 to make flights over special ocean target areas to acquire the necessary data concerning ocean wave patterns, sea state or ocean profile; (2) to add modifications to the radar to demonstrate digital data handling capability, sea state monitoring capability, backscatter sea state, and altimetry; (3) to reduce the data in the JPL radar data reduction laboratory and modify the reduction procedures as required to enhance the major ocean parameters of interest; and (4) to work with representatives of NOAA to evaluate the data and provide auxiliary data correlation.

W74-70545 **177-55-52**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
MICROWAVE RADIOMETRIC MEASUREMENT OF ICE THICKNESS
Donald P. Burcham 213-354-3028

The objective of this task is to perform ground-based experiments with radiometers operating at 1.42, 10.69, and 31.4 GHz to: (1) demonstrate the feasibility of remotely measuring the thickness of lake ice with a microwave radiometric system, (2) determine the microwave properties of newly formed sea ice and, if feasible, multiyear ice, (3) determine the feasibility of remotely measuring the thickness of sea ice with a microwave radiometric system, and (4) support the 1975-1976 AIDJEX mission by measuring the microwave signatures of various ice types and thicknesses. This is a three-year program based on a logical progression of experimentation with definitive reportable objectives for each year of experimentation. An existing system which includes dual-polarized microwave radiometers operating at 1.42 GHz, 10.69 GHz, and 31.4 GHz, data system, and data processing software, will be used to perform experiments on both controlled and natural samples of fresh water ice. These experiments will be conducted from a van or ship in the Great Lakes area and will demonstrate the feasibility of measuring the thickness of fresh water ice with microwave radiometers, and define the test techniques to be used in extending the application to sea ice.

W74-70546 **177-55-61**
Wallops Station, Wallops Island, Va.
PHYSICAL OCEANOGRAPHY AND COASTAL PROCESSES, INCLUDING MARINE DISASTERS
J. D. Oberholtzer 703-824-3411
(160-75-21; 160-75-30)

The purpose of this plan is to evaluate and demonstrate remote sensing capabilities for determining oceanographic and earth resource parameters. The objective, broadly, is to understand coastal circulation on a scale large enough to answer questions of sediment, nutrient and pollutant sources and distribution. Remote sensing applications include the determination of surface roughness, bottom typography, nutrient and pollutant loading, water color, tidal, current and thermal structures in this coastal region. The data acquisition and experimental results presentation will be closely coordinated with local, regional and national user agencies to insure that the studies have the widest possible user application. Instrumented overflights by the Wallops instrumented aircraft, other NASA aircraft and ERTS 1 will obtain the measurements to serve as the data base for the project. The results obtained from the reduction and analysis of this data replies along with sensor performance evaluations will serve as the baselines for future missions.

W74-70547 **177-55-62**
Wallops Station, Wallops Island, Va.
MAJOR APPLICATIONS DEMONSTRATION
H. E. Maurer 703-824-3411

A joint NASA Wallops/regional user resource sharing project will be planned and implemented in order to effectively transfer NASA developed remote sensing technology to the regional user. The first year will involve planning only, during which the

demonstration project will be selected from among five or six candidates on the basis of: impact of results; interest of user; and a continuing need by the user for the technology transferred to him. The implementation of the project will begin the second year.

W74-70548 **177-55-81**
Mississippi Test Facility, Bay Saint Louis.
MARSHLAND ECOLOGICAL SURVEY
R. O. Piland 601-688-2034

The Earth Resources Laboratory is conducting research investigation in Marshland Ecological Survey under the guideline of its charter as follows: (1) Conduct research investigations in the Mississippi/Louisiana/Gulf areas in the application of remote sensing, stressing the interests and needs of agencies in the area. (2) Extend these research investigations into experimental demonstration projects in cooperation with local agencies where appropriate. (3) Utilize existing aircraft and satellite programs as a primary source of remote sensing data, and collect and analyze surface data for correlation with these flight data. (4) Conduct continuing studies of user requirements of potential applications in order to guide future research efforts. The Marshland Ecological Survey will develop, remote sensing techniques and procedures necessary to produce information needed for monitoring the marshland ecology and management of coastal zone resources.

W74-70549 **177-55-82**
Mississippi Test Facility, Bay Saint Louis.
EARTH RESOURCES LABORATORY COASTAL PROCESS/ LIVING MARINE RESOURCES
E. L. Tilton, III 601-688-4256
(160-75-85)

The basic mission of the Earth Resources Laboratory is as follows: (1) Conduct research investigations in the Mississippi/ Louisiana/Gulf areas in the application of remote sensing, stressing the interest and needs of agencies in the area. (2) Extend these research investigations into experimental demonstration projects in cooperation with local agencies where appropriate. (3) Utilize existing aircraft satellite programs as a primary source of remote sensing data, and collect and analyze surface data for correlation with these flight data. (4) Conduct continuing studies of user requirements of potential applications in order to guide future research efforts. In the ERL program area of Sea Remote Sensing for FY-74, emphasis will be placed on the development of techniques and applications in Coastal Processes and Living Marine Resources. Remote measurement technique developments will concentrate primarily on water surface temperature, salinity and water color with chlorophyll and turbidity being two major parameters of interest in water color. Water surface remote temperature measurement is the most advanced of these techniques and efforts there will be primarily in the advancement of atmospheric correction methods for both aircraft and satellite systems. Several projects are already underway or are being initiated for the demonstration of the applicator of these techniques to assessment and management of living marine resources, characterization of estaurine and near shore waters and the monitoring of natural and man made impacts on the coastal environments. Results of these projects will demonstrate cost effectiveness of remote techniques and lead to the development of remote sensing system specification for transfer of the technology to user organizations. Detailed objectives and plans for FY-74 are presented in Block 15.

W74-70550 **177-56-12**
Ames Research Center, Moffett Field, Calif.
REMOTE SENSING FOR CONSERVATION MANAGEMENT AND UTILIZATION OF ANIMAL RESOURCES
H. P. Klein 415-965-5094
(160-75-26; 160-75-27)

The objectives are to use NASA/ARC expertise and facilities to help meet the national needs as defined by Public Law 92-522 (Marine Mammal Protection Act of 1972) enacted and signed in October of 1972 and to focus these abilities on the priorities of this act as defined by the National Marine Fisheries Service (NMFS) of the National Oceanographic and Atmospheric Administration (NOAA) to work with NOAA/NMFS and other NASA centers to establish the best sensing systems for each marine mammal population. Remote sensing aircraft flights based from Ames Research Center will collect assessment data of Pacific migratory marine mammals. The extent of how much of the home range of each species will be covered is dependent on need of data, capability of sensors, and amounts of funding. Efforts will concentrate on the California coastline, ocean, and island rookeries until combined systems of sensors data handling, and aircraft can cover larger areas. Ground truth will be provided by other cooperative ongoing efforts funded by NOAA and in some instances by NASA funded P.I.s at the University of California, Santa Cruz, and ARC. NOAA personnel will be aboard some flights as participants on a cooperative but nonfunded basis. The primary mode of observation and sensing will be from a twin engine aircraft with limited use of the ARC CV 990 and high altitude earth resource remote sensing aircraft. Imagery will include color aerial photography for species identification and experimental high resolution black and white or Infrared scanner data for assessment purpose. Use will be made of telemetry for mass tagging of marine mammals which will be monitored by ARC aircraft. A cooperative effort jointly funded by NOAA will use sonic buoys and long range telemetry to relay salmon fisheries data from the remote hostile Bristol Bay of the Bering Sea to the Alaskan Department of Fish and Game and NOAA via satellite.

W74-70551 **177-56-13**
Ames Research Center, Moffett Field, Calif.
GROUND-BASED PLATFORMS, BIO-INSTRUMENTATION AND ANIMAL TRACKING SYSTEMS AND TECHNIQUES
H. P. Klein 415-965-5094
(160-75-24; 160-75-26)

The objectives are to develop ground-based platforms, bio-instrumentation and telemetry systems and techniques for tracking and monitoring wild animals. Physiological sensors will be categorized, qualified, and field tested. A miniaturized bio-sensor back pack relay will be designed, built and tested. Use NASA sponsored expertise and equipment to investigate large mammal physiology and life histories both on land and at sea. Utilize Nimbus satellites to relay location, physiological, and environmental parameters to investigators and government agencies responsible for conservation and management of study species. A harness will be developed from models built from measurements and data on California Grey Whales. Combine miniaturized data storage and telemetry systems with harness structures and test on juvenile whales in the Gulf of California. Track with ship and aircraft with telemetry gear that is the same as or leads to Nimbus configurations. The design, fabrication, test and use of bio-instrumentation at University of Montana will be reviewed and guided by ARC expertise. Black and grizzly bears will be instrumented to investigate hibernation physiology, behaviour and environmental data. A computer model of grizzly bear behaviour will be tested by tracking animals which have radio collars attached to investigate their relocation behaviour. ERTS imagery and Nimbus F potential will be developed for bear, mountain sheep and elk habital studies. The special techniques of marine mammal anesthesiologists will be reviewed. Physiological functions of priority to marine mammalogy studies will be reviewed and instrumentation will be selected from ARC expertise and techniques to monitor the animals. Responses will be monitored at rest and exercise both in holding tanks and later while free roaming.

W74-70552 **177-56-61**
Wallops Station, Wallops Island, Va.
REMOTE SENSING OF ENVIRONMENTAL CHANGES RELATED TO PUBLIC HEALTH AND WELFARE PROBLEMS
E. M. Holton 703-824-3411

Environmental degradation and changes will be monitored, analyzed, and assessed; the data obtained will be correlated with public health and welfare problems. To achieve these goals, remote sensing technology involving photographic interpretation and fluorescence analysis techniques will be utilized. Characteristic fluorescence signatures of fertilizers, herbicides, systemics, detergents, insecticides, etc., are being determined in the

laboratory in fresh, brackish, and salt water. Specific fluorescence bands will be monitored during overflights to determine the concentration of these substances in various bodies of water. This might allow prediction of marsh productivity as well as potentially dangerous pollution problems. Rhodamaine B dye will be used to determine whether irrigation ditches can cause contamination of nearby well water, to map the extent of runoff from solid waste disposal areas, and to establish a technique for rapidly screening the efficacy of sewage systems. Waste Disposal areas will be mapped from aerial photography and rodent and insect breeding grounds delineated along with terrain features that might entrap or transfer bacteria. Correlation between proximity to a waste disposal area and respiratory and communicable diseases will be attempted.

W74-70553 **177-56-62**
Wallops Station, Wallops Island, Va.
REMOTE SENSING OF BIOMES, ECOSYSTEMS, ECOLOGICAL DYNAMICS AND PRODUCTIVITY PRESSURES
C. R. Vaughn 703-824-3411
(160-75-32; 160-75-01)

Various University and state multidisciplinary teams are presently studying some of the Chesapeake Bay estuary systems. One such team will be contracted to provide detailed inputs of the data requirements for wetlands study and management. Using wetlands maps constructed from ground surveys and low altitude photography, small scale photography will be analyzed for applicability to these data requirements. Spectroradiometric analysis of wetlands communities and community components will be performed by Wallops to define the best sensor system - either film filter combination or scanner channels - for delineation of these structures. Imagery will be digitized using the Wallops microdensitometer. Automated processing techniques developed by the University of Kansas and Purdue will be applied to the imagery to produce maps which will be compared with the community structures delineated by the scientists. Because of the large area involved (2000 square miles) emphasis will be placed on using the lowest scale imagery compatible with the requirements of accuracy.

W74-70554 **177-57-81**
Lyndon B. Johnson Space Center, Houston, Tex.
EARTH SURVEYS IN SUPPORT OF THE LIFE SCIENCES
C. M. Barnes 713-483-5406

This research program is designed to explore the possibilities for the use of remote sensing systems technology for the life sciences. During the past few months, the NASA and support contractors have investigated the aircraft and spacecraft imagery and ground truth data of the Earth Resources Program. The Health Applications Office has directed the acquisition of additional data pertinent to health related remote assessments of the environs. Responsible scientists in the health field have emphasized that remote sensing is not only a highly desirable way of collecting data in field situations but may indeed be the only means of acquiring such information. While the use of remote sensing technology has not yet been forcefully applied in field situations by the responsible public health authorities, preliminary data collected by the Johnson Space Center has generated considerable enthusiasm in the health community. In addition to continuing investigation into feasibility of the use of remote sensors for health purposes, it is proposed that a close liaison be developed with general life science users and regulatory agencies and that pilot-type eradication and control programs be initiated during the coming year.

OFFICE OF SPACE SCIENCE

Launch Vehicle Development SR&T

W74-70555 **180-06-50**
Goddard Space Flight Center, Greenbelt, Md.
ANALYSIS OF ADVANCED PROPULSION SYSTEM REQUIREMENTS
R. E. Coady 301-982-4731

A continuing program has been underway for several years aimed at evaluating and analyzing the capability of existing and proposed propulsion systems for accomplishing planned or proposed automated missions. The theory, analytic approaches and computer implementation necessary to conduct this work have been pursued at the Aerospace Systems Lab of Princeton University, Analytical Mechanics Associates, Inc. and by the MIT Charles Stark Draper Laboratory. Current efforts are directed at extending the capabilities of these computer programs, as well as the use of the program already developed, toward the generation of mission data for a broad range of missions and toward updating NASA's Launch Vehicle Estimating Factors booklet for solar electric propulsion. Included in the current efforts has been work directed toward making the relationship between impulsive and finite thrust trajectories mathematically explicit and the implementation of this work into an operational tool. Currently, work is in progress to extend the capabilities of present programs to include more realistic performance and environmental models. Additionally, work has begun to study the behavior of several proposed guidance schemes in an attempt to establish the criteria on which a judgment can be made about the relative merits of one mode over another. The approach to be taken in the next few years is to study selected earth orbiting, planetary and interplanetary missions where preliminary work has indicated that low thrust---

W74-70556 **180-06-51**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
ELECTRIC PROPULSION RELIABILITY
Paul J. Meeks 213-354-2546
(502-24-10)

An electric propulsion system/stage reliability code is under development. When completed, the computer code will allow propulsion system design optimization based upon failure mode analysis and mission reliability requirements. The assessed reliability of the various subsystems of an autonomous stage must meet the mission requirements. Use of the system code will provide sensitivity analysis and will provide information such as (1) where to put redundancy for highest payoff and (2) where the emphasis for increased reliability is needed. The development of the computer code will be accomplished with close coordination with the JPL Office of Quality Assurance and Reliability. This work will be fully documented for export to other NASA Centers. Failure modes of electric propulsion systems, whether as a function of time or of operational mode, will have a large effect on system mass. Reducing system mass will increase mission performance, thereby improving the economic potential of space exploration. The modular concept of electric propulsion design offers certain unique possibilities for reliability enhancement. However, a computer simulation is needed to provide system optimization in order to make a detailed study of failure modes and their subsequent effect on missions.

W74-70557 **180-06-52**
Langley Research Center, Langley Station, Va.
LAUNCH VEHICLE CONCEPTS AND ANALYSIS
Eugene S. Love 703-827-2893

The following programs will be accomplished: (1) To determine the feasibility of using launch vehicles of the Scout class to perform earth escape missions. These missions shall include probes, solar and planetary (both in the ecliptic and out-of-ecliptic planes), and planetary transfer orbits. Further, a simple means will be identified, to the extent possible, to enhance the capability of the launch vehicle to perform these missions. (2) To extend the successful design principles, experience, and operations technology of the Scout booster system by modifications which will enhance its current capability and cost effectiveness. The broad study will evaluate configurations, changes in terms of performance, cost, and scheduled phase-in with the present system. (3) To provide a trajectory analysis tool enabling a more rapid and realistic determination of the actual rocket motor performance. Any off-nominal system performance or system constants will also be revealed. This will be of special value in evaluating new configurations.

W74-70558 **180-06-60**
National Aeronautics and Space Administration, Washington, D.C.
LAUNCH VEHICLE PLANNING STUDIES
B. C. Lam 202-755-3726

The objective of this task is to provide the studies and analyses required for OSS Launch Vehicle and Propulsion Programs planning and OSS level space program planning. Individual tasks are fomulated and assigned by the Office of Space Science or by Launch Vehicle and Propulsion Programs. The contractor conducts studies and analyses (OSS planning studies, economic analyses, trade-off studies, investigations in areas of launch vehicle technology, etc) that provide a base of technical information that can be drawn upon in the formulation of program recommendations.

W74-70559 **180-11-06**
Goddard Space Flight Center, Greenbelt, Md.
ISOGRID CYLINDER TEST PROGRAM - COMBINED LOADS INCLUDING INTERNAL PRESSURE
Daniel J. Knighton 301-982-4258

The objectives of this test program are to determine the contribution of internal pressure towards increasing the buckling strength of cylindrical isogrid structures and to determine the stresses and deflections associated with bulkhead-cylinder discontinuities for use on Delta and the space shuttle. Combined axial compression, bending, shear and internal pressure loading tests are expected to provide improved prediction techniques for designing more efficient structures.

W74-70560 **180-17-50**
Marshall Space Flight Center, Huntsville, Ala.
SYSTEM PERFORMANCE AND TECHNOLOGY ASSESSMENT FOR UNMANNED MISSIONS
Gerald Wittenstein 205-453-0359

Methods and computer programs, developed under NAS12-550 and updated and tested under NAS8-26491, allow the definition of systems parameters for planned OSS missions. These parameters include data needed to identify Astrionics/Avionics subsystems and hardware requirements. The sensitivities of these requirements to mission and systems changes or modifications will be included. The methods and computer programs allow one to enter technical data of known applicable aerospace or commercial subsystems. The output will be a comparison of requirements for specific OSS missions with available subsystems. This comparison will aid NASA Management to take advantage of subsystems already developed or being developed for other programs and to identify new technology needed where applicable subsystems are not available.

W74-70561 **180-17-52**
Marshall Space Flight Center, Huntsville, Ala.
SYSTEM AND TRAJECTORY ANALYSIS
J. R. Parker 205-453-4276
(180-17-53)

The evaluation of strapdown inertial systems for launch vehicles requires a determination of the performance in the launch environment. Studies and experiments completed show that the launch environment of the vehicle modifies the static error model of the system. These effects must be identified and concepts developed and tested for reducing these errors to an acceptable level. Studies will be performed to develop guidelines for selecting subsystem approaches. Experimental studies will also be continued to quantify the sensitivity of sensors and systems to the launch environment. Specifications for a normalized, single axis inertial measuring module will be defined. The design and fabrication of a prototype electronics set for a normalized gyro will be initiated.

W74-70562 **180-17-53**
Marshall Space Flight Center, Huntsville, Ala.
DYNAMIC TESTS OF INERTIAL SENSORS
B. J. Gaines 205-453-0795
(180-17-52)

The objective is to determine the performance quality of inertial sensors designed for astrionics application. The approaches consist of the following: (1) determination of the suitability of existing methods and equipment for dynamic tests of inertial sensors developed as experimental prototypes for astrionics applications; (2) development of the necessary test data reduction methods; (3) evaluation of the sensor coefficients of designated error models for astrionics systems, with and without any error compensation equipment; and (4) performance testing with the inertial sensors combined into an astrionics sensor package.

W74-70563 **180-17-54**
Marshall Space Flight Center, Huntsville, Ala.
GUIDANCE COMPUTER TECHNOLOGY
J. B. White 205-453-4129

The coming decade of vigorous space activity by NASA and other organizations will require an increasingly reliable launch vehicle family. This includes the development of technology to provide flexible and reliable guidance computation for future space missions. High performance data processing configurations with useful lifetimes up to five years for long duration earth orbital and planetary missions are to be emphasized. Digital logic, circuits and packaging techniques are to be developed to meet the reliability and environmental constraints of these advanced missions. Emphasis will be given to continuation of research in modular computer configurations including evaluation of modular computer breadboard which has developed and fabricated by NASA Electronics Research Center. Existing software will be refined and expanded and new software developed in the areas of failure detection, switching control, and recovery. The culmination of these developments and evaluations will result in the fabrication of a breadboard modular computer system utilizing LSI and beam lead technology. Associated software will be developed concurrently.

W74-70564 **180-17-56**
Marshall Space Flight Center, Huntsville, Ala.
SOLAR ELECTRIC PROPULSION STAGE (SEPS) TECHNOLOGY
C. H. Guttman 205-453-5586
(180-17-57)

This RTOP represents the total FY-74 SEP effort excluding the solar array which is being pursued under a related RTOP (180-17-57). Under this project, SEP stage technology research and development will be continued to support advanced SEP stage definition activity and to insure technology availability for detail design and development. The objective of this project in FY-74 is not hardware development but to determine in detail SEPS subsystem technology requirements and deficiencies, to investigate the interaction of subsystems and the effect of this interaction on SEPS design, and to initiate advanced SEP stage systems simulation and to continue software development. The tasks to be pursued under this project in order of priority are: GEOSEPS guidance analysis, interplanetary low thrust guidance and performance error analysis, simulation of SEPS control system, SEPS low cost onboard computer system, SEPS mercury propellant dynamics, SEPS docking structure developmental analysis, high energy radiation effects and environment for GEOSEPS, man-in-the-loop SEPS, rendezvous and docking, and zero g propellant sloshing effects on SEPS design. A majority of these tasks are spin-offs of on-going inhouse efforts currently being worked.

W74-70565 **180-24-51**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
ENGINEERING INSTRUMENTATION
Paul J. Meeks 213-354-2546

It is the objective of this applied research program to develop and demonstrate improved electrothermal nondestructive test techniques for electroexplosive devices (EED's) and to establish methods to efficiently and reliably initiate EED's at high power levels. In addition, the efficacy and feasibility of applying developed NDT techniques for inflight periodic monitoring of EED condition will be investigated. There are two principal experimental programs associated with this plan namely; the development and demonstration of the thermal coupling technique and the bridge-wire dynamic ignition study. These two experimental activities are complementary and will be integrated so as to verify EED performance prediction. The bridgewire ignition study will require some

experimental determination of the thermal properties of various pyrotechnic and explosive materials. Hi-speed photography and infrared microscopy will be used to examine the dynamic response of bridgewires to high power level current pulses. It is planned to determine and classify the ignition failure modes that occur at high power levels with conventional devices and then to establish design modifications to reduce or eliminate such conditions. The result of this portion of the plan will be to reduce arbitrary upper power level constraints placed on conventional 1 amp-1 watt devices. The thermal coupling technique will be developed and demonstrated with EED's that have known built-in defects, such as, poor welds, incorrect loading pressure, and the absence of output charge. The thermal coupling technique will ultimately be judged on its ability to identify and qualify such defects. A computer simulation of the thermal system (i.e., the EED) response to heat flux from the output end to the bridgewire will be used as an analysis tool to assist in---

W74-70566 **180-31-52**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
LIQUID PROPULSION TECHNOLOGY
Paul J. Meeks 213-354-2546
(502-24-26)

A major objective is to demonstrate and evaluate a pre-prototype configuration bimodal rocket engine for unmanned planetary spacecraft applications. It will employ the earth-storable propellants N204/N2H4 and produce a bipropellant vacuum thrust of 4500N at 60:1 expansion area ratio. The pre-prototype model will be designed based on criteria and information generated during prior years' efforts. This engine will then be subjected to performance, margin-limit, and life testing in a vacuum environment. In conjunction with this work, a system utilizing the 4500-N (1000 lbf) thrust bimodal engine will be designed and analyzed for N204/N2H4 propellants with a duty cycle representative of an advanced planetary orbiter. A definition of overall system flexibility will be obtained through system simulation. Using the current NASA mission model as a guide, system studies will be undertaken to aid in establishing design requirements for propulsion systems using high energy propellants. An existing FLOX/MMH propulsion subsystem will be prepared this FY for further testing with F2/N2H4 propellants in FY-75 at an AFRPL vacuum test facility.

W74-70567 **180-31-51**
Lewis Research Center, Cleveland, Ohio.
THERMAL SYSTEMS MANAGEMENT
C. A. Aukerman 216-433-6223
(502-24-24; 502-24-31)

The general objectives of the programs to be conducted under this RTOP are to provide the technology required for effective design, fabrication, maintenance and operation of thermal protection systems for use with cryogenic propellants in launch vehicles and upper stages. Experimental and analytical studies will be conducted to (1) evaluate multilayer insulation performance, emphasizing the effects of critical features (such as seams, overlaps, gaps and penetrations), insulation preconditioning and surface temperatures; (2) investigate the influence of outgassing on insulation performance, including the effect of perforations; and (3) optimize multilayer insulation by selectively varying thickness and shield emissivity.

W74-70568 **180-32-51**
Langley Research Center, Langley Station, Va.
SOLID ROCKET PROPULSION SYSTEMS
Eugene S. Love 703-827-2893

A review will be made of the criteria and methods of analysis used in the design, processes, and techniques for the fabrication of solid fuel rocket motors, particularly those used in the Scout vehicle, and identify those areas where the design and/or process controls are inadequate. A study will be performed to define the extent and severity of the solid rocket motor outgassing. Optimum motor case materials and/or fabrication techniques will be selected. An investigation will be conducted to determine and verify by tests a technique for predicting the aerodynamic coefficients of control surfaces immersed in a rocket exhaust flow external to the nozzle. A study will survey the existing motors, define an optimum configuration for an upper stage motor, and select one or more candidates as the starting point for development of the optimum motor. The Apollo standard initiator will be qualified to a delay initiator assembly in a modular concept. In this concept, the Apollo standard initiator shall be used to function higher level hermetically-sealed pyrotechnic assemblies. Separate motor delay initiator assemblies will be developed to meet three different specified conditions. An investigation will be made to evaluate the effectiveness of radiographic and ultrasonic nondestructive test methods currently used for determining the acceptance of solid propellant motors. Methods for upgrading the quality of nondestructive test acceptance criteria, through improvements in existing equipment and procedures, and/or the use of advanced techniques will also be investigated. A development program will be conducted to---

W74-70569 **180-32-52**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
SOLID PROPULSION TECHNOLOGY
Paul J. Meeks 213-354-2546
(502-24-46)

Application studies will be performed to provide early identification and characterization of solid propulsion systems capable of effectively meeting future NASA missions. Studies will include: (1) kick stage solid motors, satellite apogee maneuver motors and releated earth satellite solid propulsion systems; (2) solid propulsion applications for shuttle; and (3) solids applications for unmanned planetary spacecraft. The dominant goal will be to provide timely identification and direction for supporting technology work to insure adaption capability prior to committing to a flight project. Stress will be placed on reducing future NASA mission needs to several basic classes of solid systems which are capable of multimission usage by minor modifications from mission-to-mission. Standardization will result in reducing solid propulsion system costs and also improve functional reliability. As an additional approach to reducing future development/qualification flight program costs and improving functional motor reliability of contemporary solid rocket motors, a margins limit load prediction and verification test program will be performed. Several contractors of surplus flight motors will be selected based on motor configuration and applicability of failure modes of interest to future apogee/upper stage and shuttle motor applications. Original motor analyses and test history will be reviewed by the contractor to predict load/environmental limits to cause motor failure. The motors will then be tested to verify the predicted failure level.

W74-70570 **180-70-50**
Marshall Space Flight Center, Huntsville, Ala.
ENVIRONMENTAL IMPACT OF OSS LAUNCH VEHICLE AND PROPULSION PROGRAMS
J. L. DeVries 205-453-3108

The objectives of this study are to examine the potential of the OSS launch vehicle and propulsion program to contribute to environmental contamination, determine the problems if any of significance are found, and outline an investigative approach if necessary. A joint program, in conjunction with Wallops Station, LaRC, and KSC has been established to measure and predict the concentration and dispersion of exhaust by-products from Scout, Delta, Titan 3, and other selected OSS launch vehicles. The MSFC atmospheric dispersion model is used to predict the concentration of OSS launch vehicle exhaust by-products. Ground-based and airborne measurements of engine effluents, made by LaRC, are compared with the MSFC predictions in order to validate and/or improve the MSFC atmospheric diffusion model. Any identifiable chemical atmospheric changes of the engine exhaust by-products after atmospheric exposure will be used to improve the atmospheric model. MSFC will use this improved model to identify potential environmental hazards of OSS launch vehicles and to determine possible approaches for alleviation of such hazards. MSFC will assess the worst case type environmental hazards of OSS launch vehicles under several environmental and vehicle hazard conditions, such as on-shore winds, temperature inversions, on-pad aborts, and low level vehicle destructs. If significant problems are identified, an investigative

program will be outlined to provide definitive answers to environmental questions.

Planetary Exploration SR&T - Science

W74-70571 **185-47-51**
Goddard Space Flight Center, Greenbelt, Md.
ABSOLUTE PRESSURE, ATOMIC OXYGEN, AND ENERGETIC BEAM CALIBRATION FOR MASS SPECTROMETER
H. B. Niemann 301-982-4706

The objective of this work is to refine laboratory techniques and construct test facilities for testing and calibration of instruments to measure the neutral particle composition and temperature of the planetary atmospheres. The large pressure range over which the instruments are required to operate and the different chemical properties of the various atmospheric constituents make it necessary to build several separate systems each with a limited range and flexibility which together satisfy the test requirements. A pressure calibration system has been constructed for mass spectrometer calibration with nonreactive gases, i.e., N2, O, CO2, H2, He, Ar, etc., in the pressure range from .001 to 10 to the -10th power torr. Liquid helium cryogenic pumps and sputter ion pumps are used to provide efficient pumping to low pressures without hydrocarbon contamination. High speed computer compatible data recording is planned to improve measurement accuracy and data handling efficiency. Particle beam systems of chemically active species, i.e., O, N, H, are developed for mass spectrometer calibration and gas surface interaction studies. Atomic oxygen and hydrogen are produced by thermal dissociation on heated tungsten surfaces with kinetic beam energies of approximately 0.2 eV. To simulate satellite energies, a sputter beam system is developed with the intent to produce atomic beams of nitrogen and oxygen with average kinetic energies of 10 eV. A static high pressure and temperature test facility will be designed to test mass spectrometer components and sample inlet systems. Conditions expected to be found in the lower atmosphere of Venus will be simulated.

W74-70572 **185-47-52**
Goddard Space Flight Center, Greenbelt, Md.
EXPERIMENT DEVELOPMENT FOR NEUTRAL GAS COMPOSITION MEASUREMENT IN PLANETARY ATMOSPHERES
H. B. Niemann 301-982-4706

This research plan is concerned with the overall improvement of neutral gas composition measurements planned for the atmospheres of the earth and of the planets. In general, improvements are sought in two basic areas: (1) sensor concept and application, and (2) optimization of basic instrument parameters in anticipation of restrictive mission constraints. In the first area, sensor development will be directed toward the improvement of ambient gas sampling techniques for high velocity probes into high density atmospheres (e.g., the Jovian Turbopause Probe); the design of more efficient ion sources of both the open type which provides side-energy focussing, and the closed type which increases the thermalization of the gas being measured; and development of a neutral particle retarding potential analyzer for high velocity probes. In the second area, neutral spectrometer system development will be directed toward optimizing existing techniques in view of rigorous requirements anticipated in forthcoming earth and planetary flight opportunities. This work will concentrate on (1) development of smaller, lighter, higher resoulution, less expensive analyzers using hyperbolic rods; (2) improvement of ion current detectors applicable to digital systems, emphasizing accuracy, sensitivity, and stability, and (3) development of improved digital logic and onboard data processing subsystems. Periodic earth atmosphere flight tests will be performed to evaluate developments in the ion source area and in the on-board data processing system under true flight conditions.

W74-70573 **185-47-53**
Goddard Space Flight Center, Greenbelt, Md.
DEVELOPMENT OF ION MASS SPECTROMETER FOR PLANETARY ATMOSPHERIC EXPERIMENT
H. A. Taylor, Jr. 301-982-6610

The Bennett Radio Frequency Ion Mass Spectrometer instrument is being prepared for future planetary and cometary flight opportunities. The objectives of the experiments to be performed with these instruments will be in-situ measurement of positive ions distributed in planetary ionospheres and cometary wakes. The Bennett instrument has been proven through repeated successful earth flight tests on both rockets and satellites. The most economical application of this instrument for planetary and cometary exploration is that of optimizing existing measurement techniques to provide a simple, inexpensive, and low requirement instrument capable of returning significant direct measurement results on the unknown ionosphere. To realize this objective, further refinement of the Bennett spectrometer instrument is planned in the following areas: (1) improvements in adaptive in-flight data handling and coding techniques; (2) miniaturization of electrometer and noise suppression and isolation circuits; and (3) earth atmosphere test flights of prototype instruments. The first two tasks involve electrical and mechanical design enhancements, emphasizing a controlled and reliable extension of present technology. The third task provides for a continuing program of earth flight testing involving cooperative participation as a piggyback instrument on existing and planned Javelin rocket payloads.

W74-70574 **185-47-54**
Goddard Space Flight Center, Greenbelt, Md.
EXPERIMENT DEVELOPMENT FOR THE DETERMINATION OF VENUS CLOUD PARTICLE COMPOSITION
H. B. Niemann 301-982-4706

The objective of this work is to develop a practical technique for the determination of the composition of cloud particles in the lower atmosphere of Venus. Although the complexity of the Venus cloud structure, which is expected to be at least equal to the complexity of the terrestrial cloud structure, requires a study of many different techniques, the relatively straightforward and laboratory proven method of mass spectrometers for the composition determination of solid materials and condensibles will be adopted for space flight applications. The major effort will be extended in the area of miniaturization, weight reduction, and efficiency in power consumption.

W74-70575 **185-47-55**
Goddard Space Flight Center, Greenbelt, Md.
SPECTROSCOPY AND PHOTOCHEMISTRY OF PLANETARY AND COMETARY MOLECULES
L. J. Stief 301-982-2529

The objectives of this program are to measure the optical and chemical properties of atoms and molecules which are important in understanding the composition of planetary atmospheres and comets. Emphasis is placed on those problems which are of immediate concern for interpreting the results of rocket and satellite observations. In these investigations the well known techniques of optical spectroscopy and of photochemistry are applied under well defined experimental conditions. Sophisticated techniques have been developed for data reduction and for handling the small signal levels which are usually encountered. Measurements on photodissociative excitation of CO2 have been extended to include cross sections for producing CO(a3pi), CO2(+)(A2pi), and CO2(+)(B2 sigma sub u) as a function of incident photon energy. Excitation cross sections for electron impact on CH4, NH3, and H2O have been measured for those spectral features which lie between 1100 and 2000A. The electron excitation apparatus was modified and preliminary results have been obtained for electron impact on N2 and O2 to produce emission in the EUV(lambda 76 1050A). A series of sounding rocket observations of the aurora in the EUV are planned for fiscal 74 which will complement the laboratory measurements in the EUV. An experiment has been set up at the University of Maryland, in collaboration with Dr. M. A. Coplan, which has measured cross sections for producing CO2(+) and CO in excited electronic states via charge exchange of He(+) with CO2 and CO. The flash photolysis-resonance fluorescence apparatus is now operative. Time---

W74-70576 **185-47-56**
Goddard Space Flight Center, Greenbelt, Md.
NEGATIVE IONS IN PLANETARY ATMOSPHERES
A. C. Aikin 301-982-4913

The objective is to determine the altitude distribution and species of negative ions present in planetary atmospheres such as Venus and Mars. Since negative ion formation and species will depend on the presence of minor neutral atmospheric constituents such as molecular oxygen and water vapor, identification of negative ions can be used as a tracer of these neutral constituents. The present study will simulate the lower ionosphere of a CO2 atmosphere with trace neutral constituents and identify species of negative ions. A negative ion detection system for sampling in planetary atmospheres will also be developed. This system will initially be utilized for the earth's atmosphere. The research has application to the manned and unmanned exploration of the Martian surface, since it defines the electrical environment in which systems operate. It has application to meteorology in that negative ions found in the mesosphere can be utilized as tracers to determine factors involved in large scale circulation and interaction between the stratosphere and mesosphere.

W74-70577 **185-47-66**
Ames Research Center, Moffett Field, Calif.
ATMOSPHERIC CHEMICAL PHYSICS - RESEARCH STUDIES OF PROCESSES IN PLANETARY ATMOSPHERES, COMETS AND INTERSTELLAR SPACE
Glen Goodwin 415-965-5065
(185-47-67)

The objectives are to determine products, rates, and yields of energy transfer reactions in planetary atmospheres, comets, and interstellar space. Solar and galactic radiations interact with the atmospheric constituents to produce excited and ionized species and free radicals, which then react to form other ionized and excited species, and/or neutral unexcited species, and/or reradiate spectral energy. Insight into the nature of planetary atmospheres, comets, and interstellar matter can be obtained from studies of these processes under controlled conditions. The recombination of CO and O to produce CO2 will be investigated under conditions simulating the CO2-rich atmospheres of Mars and Venus. The recombination process in the presence of Cl will also be investigated to assess the effectiveness of Cl in catalyzing the recombination reaction. This study is relevant to the CO2 photochemistry on Venus in view of the presence of HCl in its atmosphere. The ultraviolet photolysis of CH4, NH3, and H2 will be investigated and the fluoresence emission cross-sections determined. These studies will contribute to our understanding of the photochemistry of Jupiter and will provide scientific support for future Jupiter missions. The equivalent widths of the Schumann-Runge absorption bands of O2 will be determined under various pathlength-pressure conditions to assess the role of pressure broadening and its possible importance in attenuation of ultraviolet radiation in O2-rich atmospheres.

W74-70578 **185-47-67**
Ames Research Center, Moffett Field, Calif.
STRUCTURE OF PLANETARY ATMOSPHERES
Glen Goodwin 415-965-5065
(185-47-66; 384-47-66)

The basic goal is to connect atmospheric observations with theory. Immediate objectives are: (1) structure of the ionospheres of Venus, Mars, Jupiter, and the moons of Jupiter and Saturn; (2) stability against photolysis on Mars and Venus; (3) interactions of planetary ionospheres with the solar wind; (4) effects of cosmic X-ray sources on the earth's ionosphere; (5) composition of the clouds of Venus; (6) atmospheric structure of Jovian planets and Titan; and (7) mean particle sizes and optical depth of Saturn's rings. The abundance and distribution of ions and electrons, and minor constituents on Mars and Venus are being studied theoretically, using data from observations and laboratory measurements. In each case this work involves numerical solution of appropriate conservation equations; for example, solution is made for the complete set of coupled mass, momentum, and energy conservation equations in the case of the upper ionosphere of Venus. Thermal structure models have been constructed to understand the operation of the greenhouse effect of Titan. In order to understand the composition of the clouds of Venus, theoretical spectral profiles are being compared with observed values. Estimates of the particle size in the rings of Saturn are obtained from analysis of observed near IR and microwave spectra measurements.

W74-70579 **185-47-68**
Ames Research Center, Moffett Field, Calif.
PLANETARY ATMOSPHERES - STRUCTURE AND COMPOSITION
Alvin Seiff 415-965-5685
(186-68-60; 186-68-63)

Current plans to explore the planets include atmosphere entry probes to measure properties of upper and lower planetary atmospheres during descent to the surface. Comprehensive studies have defined measurement techniques and instrumentation generically suitable for such missions. One resulting experiment is part of the 1975 Viking mission payload. The Planetary Atmosphere Experiments Tests, supported in part by this RTOP, was performed to demonstrate and confirm in the earth's atmosphere the soundness of some basic concepts and instrument approaches employed in these measurements. The flight data obtained demonstrated the validity, accuracy, and usefulness of the techniques. Studies continue to optimize the approach to the Viking Project Entry Science Experiment, to evaluate effects of proposed changes and to modify and improve the planned experiments as required to satisfy constraints imposed by the lander vehicles. Current emphasis is also required to adapt and extend the PAET experiments for application to Venus probes, as planned in the Pioneer Venus Phase B studies. Aspects requiring further development and attention are, for Viking, wind measurement analysis techniques, and instrument accuracies and alignments; for Pioneer-Venus, data limited measurements of turbulence by accelerometers, and absolute accuracy and environmental tolerance of pressure and temperature sensors. Further work will also be devoted to similar experiments and planet-particular experiments for Saturn and Jupiter.

W74-70580 **185-47-69**
Ames Research Center, Moffett Field, Calif.
PLANETARY ATMOSPHERES EXPERIMENT DEVELOPMENT
Glen Goodwin 415-965-5065

The objective will be to establish the feasibility of experimentally identifying the composition of planetary atmospheres by utilizing the spectral signature of atmospheric components as measured with attenuated total reflection techniques (ATR) on atmospheric probes. The ATR techniques should be especially effective for monitoring the proposed organic and inorganic constituents of the atmospheres of Jupiter and Venus without the necessity of sample ingestion or erection of experimental components external to an atmospheric probe. The ATR technique will be applied to the measurement of the spectral characteristics of thin films of typical proposed constituents condensed onto the outside of simulated windows of an atmospheric probe. Commercially available apparatus will be employed to obtain the pertinent signatures, applying minor hardware modifications necessary for the particular requirements of the pertinent atmospheric constituents. The possibility of identifying several constituents from a layer of one constituent deposited on a sublayer of another constituent, as well as single layers of mixtures of two or more constituents, will be investigated. Based on the results of the measurements, consideration will be given to the feasibility of incorporating a typical ATR apparatus into a space experiment by considering component development requirements.

W74-70581 **185-47-71**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
ATMOSPHERIC EXPERIMENT DEVELOPMENT
Donald P. Burcham 213-354-3028
(185-47-72)

The purpose of this work is to define in detail the key investigations to be conducted in exploring the atmospheres of the planets from spacecraft. The principal objective is the definition of the optimum techniques for addressing given science goals

within a fixed mission concept with due consideration to practical restrictions and the current state of the art in the required technology. The feasibility of new techniques, and of existing techniques in new applications, is examined by numerical experiments and error analyses with supporting experimental work whenever necessary. The approach is through basic research in the following broad categories: (1) the development of new methods in radiative transfer theory relevant to remote sensing techniques; (2) methods for the inversion and interpretation of radiometric and spectroscopic measurements; (3) the definition of the relationships between practical instrument parameters and feasibility of measurements, and (4) experimental and theoretical studies of the spectroscopic properties of atmospheric gases and plausible cloud constituents under appropriate planetary conditions. The major studies to be conducted in FY-74 are: continued development of a temperature sounding and humidity mapping experiment for a spin-stabilized Venus orbiter, and continued development of techniques for the remote sensing of atmospheric structure (principally vertical temperature profile, hydrogen to helium ratio and cloud microphysics) from Outer Planet spacecraft, with emphasis on the projected JU flyby and Jupiter orbiter missions. Several new projects are described in outline. The intention is to submit these to a preliminary study with a view to expanding them in subsequent years if their usefulness and feasibility is established.

W74-70582 **185-47-72**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
THEORETICAL STUDIES - PLANETARY ATMOSPHERES
Donald P. Burcham 213-354-3028

A broad program of applied and theoretical studies related to planetary atmospheres will be conducted, with the following objectives: (1) understanding the properties and determination of the parameters of planetary atmospheres; (2) application of laboratory experimental data to understanding and interpretation of spectral features of complex planetary atmospheres, (3) applying these findings towards design of ground based and spacecraft experiments; and (4) interpretation of above data as well as other observations to aid in the evolution of valid planetary atmospheric models. This program contributes to NASA planetary missions both in its direct research relevance to planetary atmospheric science and in the maintenance within JPL of a staff of specialists who may evaluate and define scientific objectives and experiments for planetary flight projects. The studies to be conducted in FY-74 pertain to planetary atmospheric modelling, radiative transport theory, and spectroscopic theory development.

W74-70583 **185-47-80**
National Aeronautics and Space Administration, Washington, D.C.
EXPERIMENT DEVELOPMENT
R. F. Fellows 202-755-3660

The objective of tasks supported under this RTOP is to develop the instrumentation capability required for spacecraft exploration and study of planetary atmospheres and cometary gases. New concepts will be sought and evaluated, and known techniques and instruments will be modified and developed for specialized application. Studies essential to understanding the response and behavior characteristics of sensors and instruments will be conducted. Emphasis is being placed on two areas of development: (1) specialized sensors and instruments required for investigation of the lower atmosphere and cloud phenomena of Venus and Jupiter by entry probes; and (2) instrumentation and experiments required for investigations of the atmospheres of the outer planets from flyby and orbiter spacecraft.

W74-70584 **185-47-81**
National Aeronautics and Space Administration, Washington, D.C.
THEORY AND MODELS
R. F. Fellows 202-755-3660

The objective of work performed under this RTOP is to foster and to develop a broad base of theory explaining the phenomena of planetary atmospheres including their origins, evolutions, present states, and future history. Theoretical models of the atmospheres of the planets are derived, modified, critiqued, and improved on a continuous basis using the fundamental principles of physics and chemistry supplemented by the most current information available from flight experiments, laboratory research, and astronomical observations.

W74-70585 **185-47-83**
National Aeronautics and Space Administration, Washington, D.C.
SPECTROSCOPIC INVESTIGATIONS
R. F. Fellows 202-755-3660

Work performed under this RTOP includes theoretical and laboratory investigations of the components of planetary atmospheres by spectroscopic, photometric, and radiometric techniques for the purpose of obtaining data necessary for the design of flight experiments and the interpretation of data obtained by flight experiments. Also included are the necessary studies in the theory of spectroscopy and radiative transfer necessary to interpret flight data in terms of physical properties such as temperature and density profiles in addition to the usual determinations of composition. The majority of tasks are concerned with infrared and ultraviolet spectroscopic studies of gaseous species although exploratory studies to define the potential of microwave techniques are also included. Tasks also include work directed at understanding auroral and airglow emissions since spectroscopic scrutiny of these natural processes offers strong clues to the composition and characteristics of the atomic and molecular species involved.

W74-70586 **185-47-85**
National Aeronautics and Space Administration, Washington, D.C.
ATMOSPHERIC CHEMISTRY
R. F. Fellows 202-755-3660
(185-47-82; 185-47-84)

The objectives of this RTOP are to support a broad base program of laboratory investigations directed at obtaining data essential to the analysis of flight experiments and the development of new and improved theories and explanations of atmospheric chemical processes. Research included under this program includes investigations of chemical kinetics, photochemistry, reaction mechanisms, intermediates and metastable reaction species, collision processes and other phenomena connected with the interchange of energy between photons, atoms, ions, and molecules and the interaction of such species with electromagnetic radiation. Also included is research concerned with determining the physical and chemical properties of low molecular weight molecules, free radicals, and other species stable at cryogenic temperatures that are likely to be present in comets or the atmospheres of the outer planets.

W74-70587 **185-47-91**
Langley Research Center, Langley Station, Va.
PLANETARY ATMOSPHERIC PROCESSES AND MEASUREMENTS
Eugene S. Love 703-827-2893

Properties and processes of the earth's upper atmosphere, as well as the atmospheres of other planets, will be studied using ground-based and satellite measurements, laboratory simulations, and theoretical studies. Earth aeronomical measurements employing various techniques will be compared with drag measurements of the NASA-Langley Air Density Explorer satellites to obtain a more comprehensive picture of our thermosphere and exosphere. The vertical distribution of ozone in our atmosphere will be determined spectrophotometrically from ground-based measurements of satellites passing into the earth's shadow. Mariner 9 tracking data will be analyzed to determine the Martian radio refractivity profile, to develop consistent Martian atmospheric models, and to verify the techniques for future measurements of Mars. Mariner 9 solar occultation data analysis will be continued to deduce neutral atmospheric conditions near the surface of Mars and to possibly confirm, or deny, the reality of an apparent diurnal variation in the surface pressure of Mars suggested from Mariner radio refractivity data. Theoretical studies of the processes causing this variation will be continued. Studies will be continued on the effect of helium and other upper atmospheric

constituents on the density of the Martian and Venusian exosphere which in turn controls the orbital decay of planetary artificial satellites such as Mariner 9, Mars 2 and 3, and the future Viking spacecraft. Design studies and formulation of design criteria for possible instruments, measurement techniques, and spacecraft to further our understanding of planetary atmospheric processes will be continued.

W74-70588 **185-47-94**
Wallops Station, Wallops Island, Va.
EXPERIMENTAL AND THEORETICAL STUDIES OF PLANETARY ATMOSPHERES
Shardinand

The objective of this RTOP is to carry out an integrated experimental and theoretical study aimed at improving our understanding of the optical properties of planetary atmospheres including the effect of aerosols on slant path visibility through the atmosphere. Special emphasis will be placed on (1) developing and improving model atmospheres for use in remote sensing, (2) developing instrumentation for measuring optical parameters of the atmospheres, and (3) improving existing theoretical models of radiative transfer through the atmospheres containing significant amounts of particulate matter (i.e. haze, dust, ice crystals, fog droplets).

W74-70589 **185-50-60**
Ames Research Center, Moffett Field, Calif.
PLANETOLOGY: GOEMORPHOLOGY AND SURFACE PROCESSES OF PLANETARY BODIES
Glen Goodwin 415-965-5065
(383-09-52)

The objectives are to: (1) study the relative expressions of the impact processes on the production of surface features of planets and their satellites due to their differing environments and apply these results to interpretation of surface features and the geologic history of the surfaces; (2) study volcanic regions in the United States to determine the origin, structure and geomorphology of analog basaltic features; (3) determine the significant parameters governing eolian processes in the Martian environment and use this information to perform wind tunnel experiment; and (4) develop an ion microprobe for flight on follow-on missions to analyze the bulk chemistry of the soil, the atmosphere, and to measure isotopic ratios for age determinations of the Martian surface. Approaches include: (1) Calculating ablation histories of meteoritic matter entering the Martian atmosphere to determine the terminal kinetic energies and masses of irons and chondrites for conversion to cratering frequency for comparison with similar results for carbonaceous chondrites. Further, derive estimates of the flux of meteoritic masses from cometary and asteroidal sources at the orbit of Mercury and calculate the frequency of crater formation there using appropriate scaling relationships. (2) Performing theoretical studies of the effects of tidal forces on breakup of meteoroids in order to interpret different planetary responses to the same basic impact processes and explain Martian surface features detected in associated studies of Mariner photographs. (3) Carrying out field studies in the Snake River Plains, Idaho, to relate---

W74-70590 **185-50-61**
Ames Research Center, Moffett Field, Calif.
PLANETARY STUDIES
Glen Goodwin 415-969-5065
(384-50-80)

The objectives are to obtain a better understanding of selected problems pertaining to planetary surface phenomena, the composition, structure and evolution of planetary bodies and their satellites, and the origin of the solar system by means of theoretical investigations employing the results of spacecraft and ground-based experiments. Theoretical knowledge, physical insight and mathematical modeling techniques are used, together with astronomical and geological data, to construct self-consistent mathematical descriptions of planetary processes and structure. Analysis and interpretation of the results of these model calculations are applied to such topics as: the evolution of Jupiter, wind-blown surface features on Mars, and the calculation of conditions within the early solar system.

W74-70591 **185-50-71**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
PLANETOLOGY STUDIES - IMAGING
Donald P. Burcham 213-354-3028
(186-68-52; 502-33-94)

Future exploration with imaging instruments will be aimed not only at the inner planets, but will also include the outer planets of the solar system and their satellites. To explore the outer planets, the imaging instruments will be required to have lifetimes ranging from 4 to 10 years. The instruments must measure natural phenomena over a broader spectral range with greater sensitivity and better photometric stability than is achievable with current instruments. The proposed effort is intended to provide for use on future planetary spacecraft, imaging instruments capable of meeting these broad requirements. A silicon vidicon camera will be developed to the point of demonstrating the feasibility of adapting silicon vidicons to Mariner type imaging instruments. Included will be a design capable of cooling the vidicon target to -40 C. The mechanical design must be capable of supporting the vidicon in not only the anticipated thermal operating environment, but also the launch environment. Upon completion of the demonstration of thermal and mechanical design feasibility, this task will refocus on development of solid state sensor imaging instruments. Solid state sensors are becoming available which provide in addition to the advantages associated with silicon vidicons (increased sensitivity, broader spectral response, longer life) possible further increases in sensivity coupled with reduced complexity and lower weight. These advantages will translate into lower cost for imaging experiments. Over a several year period, linear and area array cameras will be developed utilizing the most recent technology available in imaging solid state sensors. The instruments will be simpler and have less impact on the spacecraft than current designs since fewer interfaces will be required, and the increased sensitivity can be used to relax spacecraft stability requirements.

W74-70592 **185-50-90**
Langley Research Center, Langley Station, Va.
REMOTE DETECTION OF SURFACE PROPERTIES OF PLANETS
Eugene S. Love 703-827-2893

The objective of this research is the investigation of planetary surface properties through analyses of the photometric and polarimetric characteristics of solar radiation that has been reflected from the planet and is detected by planetary orbiters or earth-based instruments. Included among the soil properties to be studied in this manner are chemical composition, particle sizes, particle phase functions (i.e., individual scattering laws), interparticle relationships, degree of multiple scattering, and types of large-scale surface topographies. The theoretical part of the research involves rigorous derivations of photometric functions, quantitative treatments of polarization phenomena, and studies of the effects of rough topographies on brightness measurements. A variety of photometric and polarimetric experiments on laboratory soil samples will serve to check, refine, and supplement the theoretical expressions, which can then be used to interpret existing planetary measurements.

Planetary Exploration SR&T - Advanced Technical Development

W74-70593 **186-68-52**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
IMAGING SYSTEM TECHNOLOGY FOR PLANETARY MISSIONS
Rob R. McDonald 213-354-6186
(185-50-71; 502-33-94)

A need exists in planetary exploration for a low cost, long life imaging instrument which is adaptible to more than one mission without major redesign. Broader spectral capabilities and higher sensitivities than have existed on previous planetary imaging instruments is also very desirable. The initial objective of this effort will be to improve the capabilities of a Mariner type imaging

instrument, using a silicon vidicon, in the areas of instrument lifetime, spectral coverage, and sensitivity. Commencing in fiscal year '74, this task will focus on the utilization of solid state imaging sensors in developing a low cost imaging instrument for planetary exploration. The development will stress low cost both in the instrument and in potential spacecraft systems by considering system interface complexity, and data processing requirements as the instrument evolves. It is anticipated that instruments resulting from this development may be candidates for flight programs as early as 1979. The development will, in late FY-75, shift from a linear array to an area array camera. The area array instrument will perform in a framing mode similar to that of the current Mariner type cameras. A modular design approach will be used which will minimize the changes required to adapt the camera to any specific spacecraft. It is expected that this development will provide an instrument capable of improved performance over current instruments, and at the same time result in lower cost for the support of the imaging experiment.

W74-70594 **186-68-55**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
G AND C TECHNOLOGY FOR MARS ROVING VEHICLES
Rob R. McDonald 213-354-6186

The work proposed under this RTOP will provide technical assistance and direction to two NASA Headquarters university research contracts at Cornell University and Rensselaer Polytechnic Institute. These contracts provide for research and advanced development in the area of Mars surface exploration. In particular, the work is directed toward developing subsystem and component technology for an unmanned Mars roving vehicle. In addition, new tasks for Cornell University and Rensselaer Polytechnic Institute will be developed.

W74-70595 **186-68-60**
Ames Research Center, Moffett Field, Calif.
VENUS ENTRY PROBE TECHNOLOGY
J. V. Foster 415-965-5083
(186-68-63)

The objective of this effort is to define and optimize a system and subsystem based on the selected technologies and design concepts required for the proposed Pioneer Venus missions. The approach will take the existing studies as a baseline and perform additional system analysis and tradeoff studies in all spacecraft/probe areas for the purpose of defining one optimum choice for each subsystem and system required to support the mission objectives. The spacecraft and probe areas to be studied include: the definition of the total probe and spacecraft subsystem vs. the mission objectives; probe descent thermal control designs; probe aerodynamics studies; probe acceleration test studies; low bit rate modulation and coding studies; stable oscillator and transponder designs; communication propagation effects of Venus atmosphere; detail design of critical structural subsystems; mission analysis; and maneuver and navigation studies.

W74-70596 **186-68-62**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
PROPELLANT COMPATIBILITY WITH MATERIALS FOR LONG DURATION MISSIONS
Rob R. McDonald 213-354-6186

The objective of this plan is to provide the technology for propellant/material compatibility that will be used on future outer planetary missions. Current objectives include work to determine which materials are acceptably inert for use in the construction of propulsion subsystem components in contact with earth storable liquid propellants for long duration missions. The test program involves continuing actual specimen storage tests in a controlled environment using the compatibility test facility at the JPL Edwards Test Station. Detailed chemical and physical analyses of specimens and propellants will be performed after specific storage periods and a rating assigned for design purposes.

W74-70597 **186-68-63**
Ames Research Center, Moffett Field, Calif.
PIONEER VENUS SCIENTIFIC INSTRUMENT DEVELOPMENT
J. V. Foster 415-965-5083
(186-68-60)

The objective of this effort is the development of scientific instruments and theoretical investigations for the Pioneer Venus 1978 multiprobe mission. The approach to be taken is to conduct vital instrument technology studies to initiate advanced development of certain instruments requiring long lead planning and feasibility studies to insure readiness to meet program integration and launch schedules, and to initiate conceptual design and interface definition of all instruments selected for development, in support of the system definition design studies.

W74-70598 **186-68-64**
Goddard Space Flight Center, Greenbelt, Md.
COMETARY SCIENCE STUDY AND RESEARCH
M. J. Mumma 301-982-6994

The objectives of this RTOP are: (1) to initiate and stimulate laboratory studies on scientific questions which are crucial to the sucess of an eventual comet mission; (2) to coordinate and stimulate near-earth observations of selected comets, to conduct continuing studies of mission configurations, and to calculate accurate ephemerides of selected comets; and (3) to conduct relevant spacecraft studies. Laboratory studies will be performed on the techniques available for measuring the parent molecular species present in the coma. Particular attention will be paid to the fast neutral molecule fragmentation problem which is expected to complicate the interpretation of data obtained with a neutral mass spectrometer operated in the stagnation mode. Design and development work will be carried out on an ion composition detector suitable for fly-by missions. The degree of image resolution needed for scientific studies of the nucleus will be determined and the instrument best suited for these observations will be identified. Specific mission-oriented spectroscopic observations of selected comets will be performed. Accurate ephemerides of possible target comets will be calculated and various mission configurations will be studied. Preliminary spacecraft studies will be carried out stressing the concept of commonality, and thermal as well as structural studies will be performed.

W74-70599 **186-68-65**
Ames Research Center, Moffett Field, Calif.
PIONEER FOLLOW ON MISSION TECHNOLOGY
J. V. Foster 415-965-5083
(186-68-60; 186-68-63)

The objective is to develop basic spacecraft and prode configurations, using existing technology, as close as possible to Pioneer F/G and PAET configurations, respectively consistant with specific mission requirements. This will provide the basis for the realistic estimates of performance; costs, reliability, and scheduling so vital to project definition and decision making. This can only be accomplished by understanding the required technology, subsystems, and the respective interfaces. The approach is to concentrate on the most critical areas first, understand the technology requirements, evaluate alternatives, and investigate the most attractive but unproven concepts. Emphasis will be placed on obtaining experimental data. Evaluation and application of existing technology will have the highest priority. All efforts will be primarily hardware oriented and related to specific missions.

Physics and Astronomy SR&T

W74-70600 **188-36-55**
Ames Research Center, Moffett Field, Calif.
MAGNETOSPHERIC PHYSICS - PARTICLES AND PARTICLE/FIELD INTERACTION
Glen Goodwin 415-965-5065
(385-36-01)

The objective of this RTOP is to provide for investigation of techniques to improve space plasma and magnetic field measurements and to improve understanding of space plasma and magnetic field observations and their relation to the sun and

the interstellar medium. Techniques to improve the lifetime, reliability, sensitivity, sampling rate, dynamic range, and resolution of space plasma experiments are studied. Means for improvement of measurement resolutions for the individual plasma parameters, the temperature, density, velocity vector and temperature anisotropy, and investigation of techniques for improvement of calibration procedures and calibration data analysis are included. Theoretical studies provide designs of plasma analyzers for testing in the laboratory. The number and position of flux collectors, position and attitude of particle multipliers, suppression of secondary electrons, shapes for apertures, post-analyzer electric field requirements, and optimum electric field configurations for both the energy to charge analyzer section and deflection plates for sampling a range of incident directions are covered. Laboratory sources of simulated space plasmas and calibration beams are prepared. Verification of instrument performance is accomplished using these sources. Computer controlled calibration of flight experiments is performed. Calibration data is processed by computers at the Ames Computation Center. A variety of charge collection techniques and single particle counting devices are tested. For space magnetic measurements, new fluxgate drive techniques, core compositions, and arrangements for minimum noise are evaluated. Theoretical studies of models of the solar plasma have been accomplished.

W74-70601 **188-36-55**
Goddard Space Flight Center, Greenbelt, Md.
MAGNETODYNAMICS-NONTHERMAL PLASMAS
K. W. Ogilvie 301-982-5904

The object of this research is to increase the knowledge and understanding of nonthermal plasmas occurring in nature, and also to improve the theoretical description of their properties. This requires a concomitant improvement in measurement techniques, and interpretation of appropriate space and laboratory experiments.

W74-70602 **188-36-55**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
MAGNETOSPHERIC PHYSICS: MAGNETODYNAMICS
Donald P. Burcham 213-354-3028

The major objective is to develop the vector helium magnetometer for use on deep space missions where extremely weak interplanetary or interstellar fields are to be measured and where intense planetary fields may also be encountered. Tests and experiments will be carried out to expose the underlying principles of operation and design and to develop improved components, a more optimum design, and new models of operation. A variety of models and their generalizations have been proposed to explain the double shock system and piston which is produced by either a solar flare, or which results from the interaction of a fast (M-region) beam with the quiescent solar wind. The OGO 5 high data rate instruments have recorded the first detailed observation of such an event. There are several peculiarities in the structure, not covered by the present theories. In particular the two-humped density and energy profiles are interesting and unexpected. A careful examination of the evidence strongly implies that the event was caused by the eruption of a flare at the site of origin of an M-region beam. Pioneer 9 recorded the same shock ensemble 2 x 10 to the 7th power km upstream in the solar wind; M. Dryer of NOAA has invited us to join his group in a further analysis of the event.

W74-70603 **188-36-56**
Goddard Space Flight Center, Greenbelt, Md.
MAGNETOSPHERIC PHYSICS - PARTICLES AND PARTICLE/PHOTON INTERACTIONS
James P. Heppner 301-982-4797

The objectives are: (1) to conceive, design, develop, and test new techniques for space measurements of electric fields, magnetic fields, auroral particles, trapped particles, solar-interplanetary particles, plasma waves, wave particle interactions, photon-particle interactions, plasma composition, ionospheric winds, electron density, and atomic and molecular collision processes with particular emphasis on magnetospheric and ionospheric regions; and (2) to analyze problems and conduct theoretical studies in magnetodynamics, plasma physics, and atomic and molecular interactions. The approach includes detector and supporting electronics, design, laboratory and contractor fabrication and testing, and theoretical studies of field and particle phenomena and distributions in space. This effort is expected to produce: flight instrumentation having the capability to make measurements that previously have not been possible, particularly in areas where there are significant gaps in our knowledge as a consequence of there being few or no measurements, accurate models of fields in space which have both scientific and technological utility; accurate models of fields in space which have both scientific and technological utility; indices which describe the instantaneous degree of disturbance in the ionosphere and magnetosphere; advances in the understanding of plasma instabilities; and new techniques for studying the transport of ion and neutral particles in the ionosphere.

W74-70604 **188-36-56**
Langley Research Center, Langley Station, Va.
MAGNETOSPHERIC PHYSICS
Eugene S. Love 703-827-2893

The overall objective of this work is to accurately measure the constituent number density of the terrestrial thermosphere (100 to 300 km). The approach centers on the development of a unique molecular beam mass spectrometer system which virtually eliminates gas-surface interactions and makes possible the accurate measurement of reactive gases such as atomic oxygen. The feasibility of this instrument design for measurement of reactive gases in the atmosphere has been demonstrated by theoretical and experimental work. This work has included design and tests of engineering models of the primary instrument components such as the ion source, mass separator, and ion collector system. Studies of vehicle requirements for flight measurements with this instrument have also been initiated and these preliminary studies indicate that all vehicle requirements can be met by using the third stage of the Scout vehicle or the second stage of a Delta vehicle with only modest modifications.

W74-70605 **188-36-56**
Ames Research Center, Moffett Field, Calif.
MAGNETOSPHERIC PHYSICS - PARTICLES AND PARTICLE/PHOTON INTERACTIONS (AERONOMY)
Glen Goodwin 415-965-5065
(185-47-67)

The objective is to investigate the physics of the earth's topside ionosphere and plasmasphere and the coupling of these regions with the magnetosphere and solar wind. Theoretical studies of the thermal charged-particle composition, density, and temperatures are being performed. Computer programs are being coded based on the continuity, momentum, and energy balance equations appropriate to these regions. Data from the Alouette, ISIS, and other satellites will be used as boundary conditions. Special correlative studies are also being performed to investigate the global nature of certain anomalous features, e.g., the plasmapause and ionospheric troughs. The results of these efforts are vital to the understanding of the earth's charged particle environment, and have application to communications between terminals immersed in these media. The theory and techniques involved are applicable to the studies of atmospheres and ionospheres of other planets. Preliminary efforts are being initiated to investigate the charged particle environment of the Venus and Jupiter ionosphere.

W74-70606 **188-36-64**
Goddard Space Flight Center, Greenbelt, Md.
SHUTTLE APPLICATIONS OF IONOSPHERIC PLASMA EXPERIMENTS
H. A. Taylor, Jr. 301-982-6610

The space shuttle provides a unique opportunity for both basic and applied ionospheric plasma-aeronomy experiments. A series of experimental studies are proposed with the objective of (1) defining new experimental research concepts, and (2) optimizing existing experimental techniques in anticipation of unique requirements for the in-situ and sub-satellite operating modes anticipated. The studies are in the areas of direct and remote plasma measurements, sensor-plasma interactions, and plasma perturbations relevant to defining solar wind-

magnetosphere-atmosphere coupling. The scope of these studies ranges from fundamental plasma physics to the investigation of how solar energy is deposited at high latitudes, perturbing the lower layers of the atmosphere. The study of plasma diagnostics will consider both in-situ measurements from the shuttle as well as coordinated measurements using sub-satellites released from, and subsequently retrieved by the shuttle, and remote sensing techniques. Methods of wave-particle interaction studies, based upon natural and stimulated perturbations will be examined using the shuttle to satellite link concept. In the area of sensor-plasma interactions, problems of fundamental plasma physics will be explored, emphasizing methods which cannot be adequately simulated in an earth laboratory. These problems are inherent to the complete understanding of direct measurement techniques for thermal and energetic plasma detection, as well as the interpretation of both rf and lf signal transmission and reception techniques in a rarefied plasma.

W74-70607 **188-38-51**
National Aeronautics and Space Administration, Washington, D.C.
DEVELOPMENT OF EXPERIMENTS AND HARDWARE FOR SOLAR PHYSICS RESEARCH
Goetz K. Oertel 202-755-8490

The objective is the development of experiments for space or laboratory application to solar physics research and the development of critical technology items which are needed for solar observations, or which can improve them significantly. Included are the following activities: (1) development of a device for the production of optical components for use in solar and astronomical telescopes, spectrographs, etc., on the ground and in space; (2) development of techniques for improving the performance of optical instrumentation in space and on the ground; (3) development of techniques for accurate calibration of solar experiments in space and on the ground in parts of the spectrum where the available accuracy is insufficient for effective use of data from space; (4) development of novel techniques for increasing the information value of present solar experiments; and (5) development of improved ground-based instrumentation for obtaining solar data in support of spaceflight solar experiments.

W74-70608 **188-38-51**
Goddard Space Flight Center, Greenbelt, Md.
DEVELOPMENT OF EXPERIMENTS AND HARDWARE FOR SOLAR PHYSICS RESEARCH
J. F. Osantowski 301-982-5861

A research program to develop or improve critical technology items principally, but not exclusively, for solar physics research and to supply critical data required by scientists in designing and/or proposing advanced instrumentation for space or ground based observations is described. Specifically, the development of specialized optical components, the development or improvement of optical instrumentation, and the development or improvement of various techniques or instruments for support of solar observations is included. To accomplish this objective GSFC is conducting in-house and contract experimental theoretical studies in the following technology: (1) Design, fabrication, and testing of glancing incidence optical systems for the 8A to 300A spectral region including the problems of increased energy throughput and scattering, (2) diffraction grating technology especially that related to the production of large gratings required for high resolution low light level ground based observations. Other technology areas will be included to support current programs or problem areas identified by the solar physics community. References for identifying key technology include NASA Document SP-213, "A Long Range Program in Space Astronomy" and working group reports such as the Solar Physics Working Group.

W74-70609 **188-38-52**
Marshall Space Flight Center, Huntsville, Ala.
GROUND BASED OBSERVATIONS OF THE SUN
W. C. Snoddy 205-453-3103

The real-time solar magnetograph, being built jointly by the Naval Research Labs and MSFC, will allow studies of small scale variations of the sun's magnetic field in order to determine this role in solar activity. The system uses a narrow band filter, polarizers, and a SEC vidicon TV system to measure the Zeeman effect in chromospheric absorption lines. In direct support of the real-time solar magnetograph, a study will be undertaken with the objective to determine the basic phenomena involved in the eruption of solar flares by studying the interactions of the solar plasma and local magnetic field and the absorption line profiles and interpret them on the basis of these interactions. The third objective of this study is to observe and investigate millimeter emissions from the sun at the shortest practical radio wavelength (i.e. three millimeters) before, during, and after solar events and during the quiet sun and to correlate the results with solar magnetograph, H-alpha records, and solar flare information. The results will be used to determine the correlation between millimeter emissions and solar activity for possible flare prediction and as a basis for a more complete understanding of the physical processes in the solar chromosphere through the comparison of observed data with that predicted by current solar models.

W74-70610 **188-38-52**
Goddard Space Flight Center, Greenbelt, Md.
GROUND BASED OBSERVATIONS OF THE SUN
J. C. Brandt 301-982-4701

The development of an observatory to determine solar wind properties at remote locations in the solar system by recording and analyzing the properties of ionic comet tails is continuing. A precision roll film transport has been installed in the comet camera. The Zeiss filtergraph previously used to obtain supporting observations for the GSFC OSO-5 wheel experiment is dedicated to OSO-7 support, and provides live video H-alpha images to the OSO Control Center and GSFC OSO-7 experimenters. Sounding rocket experiments are also supported in this manner. Photographic spectroscopy of active and quiescent prominences and other solar phenomena are performed with a 24-inch reflector and universal spectrograph at Capilla Peak. A coronal photometry system, intended to obtain brightness maps of the corona during total eclipses of the sun with a high accuracy in relative point-to-point photometry was tested at the 1972 Quebec eclipse and will be operated at future eclipses when weather conditions permit.

W74-70611 **188-38-52**
National Aeronautics and Space Administration, Washington, D.C.
GROUND-BASED OBSERVATIONS OF THE SUN
Goetz K. Oertel 202-755-8490

Ground-based observations of the sun in wavelengths for which the atmosphere is transparent are carried out at a number of suitable observatories and the ground stations throughout the United States. The purpose of these ground-based observations is to obtain information on the solar atmosphere from the photosphere and sun spots, to the chromosphere and the corona, and on the fine and gross structure of the solar atmosphere, and activity in it. This information is then used in correlation with observations from sounding rockets, OSOs, ATM and other spacecraft to determine the physical conditions in the objects studies, and to understand the physical mechanisms at work in them. Specifically the following types of activity are covered under this RTOP (ground-based here refers to aircraft and balloons as well as to fixed installations on the ground): (1) the definition and design of experiments for ground-based observatories; (2) the construction or purchase and operation of such experiments; (3) the observing of the sun, and features in it, from the ground; (4) the analysis of ground-based data in correlation with data from space or from other ground-based observatories; and (5) scientific interpretation in terms of physical conditions and mechanisms.

W74-70612 **188-38-53**
Goddard Space Flight Center, Greenbelt, Md.
EXPERIMENT DEVELOPMENT - LABORATORY AND THEORETICAL SOLAR PHYSICS
J. C. Brandt 301-982-4701

Research toward improved systems for solar observations in the EUV, X-ray, and gamma ray regions is being pursued through

the development of prototype collimator systems and detectors for these wavelengths. The X-ray and EUV scattering properties of surfaces produced by various polishing techniques is being studied. Research into improved hard X-ray detectors emphasizes the objective of extending the energy range of observation to 20 Mev. Use of a passive Li impregnated Bismuth shield offers a substantial improvement over existing methods. Electronics are being developed, which, together with existing crystal and mechanical fixtures, will produce a detector able to record the spectrum of a solar X-ray burst with 100 milliseconds resolution. Detector work begins on a multiple chamber counter capable of simultaneously recording soft, medium, and hard X-rays. Design of high resolution coronal spectrometer/polarimeters for the wavelength ranges 1-20 A and 1200-1500 A is underway and bench testing will be carried out. COS/MOS type integrated ciruits which may have reduced power needs, volume and weight will continue to be environmentally tested in typical space solar experiment electronic units. Developmental work includes an imaging infrared up-converter for use at 5 microns. Development and implementation of imaging detectors for visible-light solar physics includes line profile devices and vidicon techniques. Methods for improved solar observations at radio wavelengths include mm-wave radiometers and interferometry.

W74-70613 **188-38-53**
National Aeronautics and Space Administration, Washington, D.C.
LABORATORY AND THEORETICAL SOLAR PHYSICS
Goetz K. Oertel 202-755-8490

Laboratory and theoretical studies are carried out on current problems in solar astronomy and solar physics, and on important areas of atomic and molecular physics which are contributing basic information as required for the analysis or understanding of solar data from the ground and from space. Theoretical studies of the sun include the following types of activity: (1) the analysis of ground-based and space data in terms of models of the solar atmosphere activity, or structures; (2) scientific interpretation in terms of physical conditions and mechanisms; and (3) prediction of future events on the sun, such as predictions of coronal structures from features observable on the disk; of the development of future active regions from magnetic and H-alpha features; and the occurrence of flares from magnetic field complexity and configuration. Theoretical and laboratory studies in atomic and molecular physics include these activities: The measurement or computation of atomic or molecular quantities such as wavelength energy levels, f-values, line broadening parameters, ionization and excitation functions, etc.; and the production of plasmas which simulate by scaling part of all of the conditions in particular solar phenomena or structures in the laboratory.

W74-70614 **188-38-53**
Langley Research Center, Langley Station, Va.
LABORATORY AND THEORETICAL SOLAR PHYSICS
Eugene S. Love 703-827-2893

The principal objective is to generate and to identify some of the visible coronal emission lines. While the majority of the observed lines have been theoretically classified as forbidden transitions (forbidden in the sense that the transition violates a first-approximation quantum-mechanical selection rule) they have never been observed in the laboratory because of the high stages of ionization that correspond to these transitions. The initial lines to be investigated are 5536A (though to be Ar X), 6917A (thought to be Ar XI), and 8476A (thought to be Ar X). A second objective is to produce and identify spectral lines of highly ionized atoms of astrophysical interest in the far ultraviolet and soft X-ray regions. In particular, those elements observed in the sun will be introduced so that identification of laboratory lines will be consistent with solar spectra obtained by rocket and satellite-borne spectrographs. The theta-pinch facility will be used to generate the radiating plasma. The one-megajoule theta-pinch facility produces a plasma of sufficient temperature and density to produce Ar X through Ar XIII. Observation of the normal transition from these ions simultaneously with the visible line would confirm the stage of ionization involved in the emission of the visible corona lines. Theoretical intensities, oscillator strengths and the energies involved in these transitions will be calculated as needed using the wavefunctions generated by a Hartee-Fock computer program. This procedure should not only classify the transition and element but should also provide a determination of the oscillator strength. This same procedure will also apply--

W74-70615 **188-38-64**
National Aeronautics and Space Administration, Washington, D.C.
DEFINITION OF SOLAR PHYSICS EXPERIMENTS FOR SPACE SHUTTLE
Goetz K. Oertel 202-755-8490

The objective of the effort under this RTOP is the early definition of various types of solar instrumentation, for flight on the space shuttle, required for obtaining data necessary to the pursuit of solar research goals identified for the 1980s. The following activities are among those included: (1) preliminary design of instruments to meet observational requirements, as determined for the shuttle era, for improved spatial, spectral and time resolution, covering spectral ranges from gamma-rays and X-rays up through the infrared. Types of instruments include telescopes, photoheliographs, spectrometers, spectrographs, spectroheliographs, coronagraphs, polarimeters, magnetographs, solid state detectors, spark chambers, etc.; (2) development of methods to exploit fully the advantages and capabilities of shuttle oriented solar observations, by incorporating instrument design concepts which permit maximum utilization of the presence of man as an observer, an instrument operator and a technician. Implicit in the design would be built-in maintainability and the capability for changeout of the instrument or major modules or components; (3) studies to determine techniques and methodology for application toward developing instruments at significantly lower cost, without sacrificing performance or reliability; and (4) technology development in critical areas of concern in instrument design such as optical surfaces, filters, crystals, coatings, grating, detectors, etc.

W74-70616 **188-38-64**
Goddard Space Flight Center, Greenbelt, Md.
DEVELOPMENT OF SHUTTLE PAYLOADS FOR THE STUDY OF SOLAR FLARES AND FLARE RELATED PHENOMENA
K. J. Frost 301-982-4811

The Laboratory for Solar Physics and the Optics Branch, GSFC, propose to build a group of instruments to observe solar flares and related solar phenomena from shuttle sortie and free-flier platforms in 1979, 1980, and 1981. The scientific objective of this payload will be to advance our understanding of the nature of the mechanism of a solar flare. This will be done by observing a flare over a wide range of the electromagnetic spectrum from the visible to the gamma-ray region. A number of different instruments will be required to cover this range. They will be selected on the basis of making comprehensive measurements in their specific wavelength regions in a format which is coordinated with and complimentary to the other instruments in the payload. For example, all instruments will operate with the same temporal and spatial resolution to the maximum possible extent. The instruments considered for this payload are: (1) a solar telescope (photoheliograph) with an aperture greater than 65 cm, and (2) a high resolution 1000 to 2850 A spectrometer used at the focus of the telescope and observing line profiles from the chromosphere and the transition region.

W74-70617 **188-41-51**
National Aeronautics and Space Administration, Washington, D.C.
ULTRAVIOLET (UV) AND OPTICAL ASTRONOMY
N. G. Roman 202-755-3649

The objective is the advancement of stellar and galactic astronomy through observations and interpretations of data secured in the ultraviolet and visible electromagnetic portions of the spectrum. The emphasis is on research in direct support of on-going flight programs or in anticipation and preparation for future ones. The four elements supported are laboratory astrophysical studies, theoretical astrophysics, instrumentation development, and direct observational programs. A balanced program involving all these elements is required in order to insure

full utilization and healthy development of the space science program with the goal of the advancement of our understanding of the universe. The approach consists of the following: develop theoretical models, perform theoretical studies, and determine basic atomic and molecular parameters. Interpretation of data, especially that obtained in the relatively unexplored UV spectral region, requires the additional information provided by these efforts. A broad and sound theoretical framework allows new observations to be interpreted and new directions to be instituted. In addition to atomic and molecular physics, specific areas of study include stellar atmospheres, stellar systems, and cosmology---

W74-70618 **188-41-51**
Langley Research Center, Langley Station, Va.
UV AND OPTICAL ASTRONOMY (COMPUTATIONAL PHYSICS)
Eugene S. Love 703-827-2893

New and improved computer models will be developed to investigate the evolution and structure of various systems of astrophysical interest, such as spiral galaxies, the asteroid belt and Saturn's rings. Galaxy related problems that will be studied are the method by which spiral galaxies transfer their angular momentum outwards. Another problem to be investigated is the density wave theory proposed to explain the spiral structure of galaxies. Computer experiments testing the density wave theory without making the approximations required in an analytical treatment will be performed. Numerical' experiments on the evolution of the asteroid belt will be performed. In particular, resonant effects caused by the commensurability of asteroids with Jupiter will be investigated. Similar calculations will be made for Saturn's rings. Another problem to be investigated is the particle acceleration and other phenomena occurring in solar flares. It appears that particle acceleration occurs near magnetic neutral points and involves magnetic flux annihilation in solar flares, in laboratory experiments, such as the plasma focus and possibly also in phenomena on a galactic scale.

W74-70619 **188-41-51**
Goddard Space Flight Center, Greenbelt, Md.
UV AND OPTICAL ASTRONOMY
Albert Boggess 301-982-5103

The objective is to pursue a long range program in astronomical research, with emphasis on optical observations, theoretical astrophysics, and other specific topics of special interest to NASA. The effort includes operation of ground telescopes, development of new instrumentation for ground and rocket use, data interpretation, and theoretical studies. Spectroscopic and photometric data are obtained from ground and rocket telescopes in order to analyze the properties of stellar atmospheres and the interstellar medium. Model atmospheres are being developed to compare with observation, particular attention being paid to nonequilibrium phenomena. Additional tasks include calculations of fundamental physical parameters of astrophysical interest, investigations of convective energy transport, and some stellar population problems.

W74-70620 **188-41-51**
Marshall Space Flight Center, Huntsville, Ala.
UV AND OPTICAL ASTRONOMY
E. R. Miller 205-453-3103

The objectives are to perform ground-based visible and near IR filter photometry of binary stars, long period mira variables, Seyfert galaxies, and magnetic variable stars; and to carry out optical and infrared observations and theoretical studies of galactic and extragalactic objects in which energetic processes may be taking place. The above data will be used in support of several flight experiments and projects now under development at MSFC. Measurements will be performed using equipment which is essentially already developed and on hand. The 30 and 49 cm telescopes at MSFC and the 150 cm telescope at Tucson, Arizona will be used.

W74-70621 **188-41-52**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
RADIO ASTRONOMY
Donald P. Burcham 213-354-3028

This RTOP uses the unique facilities of NASA's Deep Space Instrumentation Facility (DSIF) to find microwave spectral lines of interstellar atoms and molecules at X-band (8 GHz) and K-band (15 GHz), regions in which NASA's receiving capabilities are the best in the world. Concurrently, a laboratory microwave spectroscopy program is carried out in order to interpret the results of the observations program as to molecular species, abundance within the source, and the Doppler shift of the source itself. DSIF equipment to be used includes the 64m Goldstone antenna; K-band and X-band wideband low noise feeds, masers, and receivers; a wideband digital correlator spectrum analyzer; calibrated nose sources, and programmable local oscillators. This DSIF equipment either already exists or is being developed for programs supported by the Office of Tracking and Data Acquisition (OTDA). The spectrometer system to be used in the the laboratory investigations includes a Stark modulation spectrometer and associated programmable digital data handling and control equipment. Fundamental questions in stellar and galactic evolution to be answered by interstellar microwave spectroscopy include the galactic molecular and isotope distribution and the isotopic abundance ratios; the velocity distribution of interstellar material; and the causes of anomalous interstellar molecular spectral line intensities. Of particular interest is the location and abundance of complex interstellar molecules, because the mechanism that allows the creation and retention of such molecules is presently unknown.

W74-70622 **188-41-52**
Goddard Space Flight Center, Greenbelt, Md.
GROUND-BASED RADIO ASTRONOMY
R. G. Stone 301-982-4631

The objective of the Ground Based Radio Astronomy Program is to provide a better understanding of the dynamics and composition of astrophysical plasmas in objects such as radio galaxies, quasars, supernovae, pulsars, and solar system sources such as the Sun and Jupiter through the high angular and time resolution observations of radio emission from these objects. Radio astronomy has provided new insight into such problems which could not have been gained from observations in other parts of the spectrum such as the visible or UV region. The interpretation of source spectral and spatial distribution in terms of our knowledge of plasmas and high energy processes leads to knowledge of the evolution of the source and of the magnetic field, energetic particle composition, and dynamic processes within the source. The approach taken involves the use and development of high resolution radio telescopes which permit remote observations of phenomena occuring in extensive and inaccessible regions.

W74-70623 **188-41-54**
National Aeronautics and Space Administration, Washington, D.C.
RELATIVITY
N. G. Roman 202-755-3649

The primary objective is to make experimental tests of the theory of relativity and thereby elucidate the interrelationship among space, time, and gravity. In particular, the test of Einstein's General Theory of Relativity is paramount. This formulation is fundamental and of high scientific interest. Experimental verification is difficult, but the ability to orbit large, complex, and extremely precise apparatus, shielded from deleterious perturbations should obviate them. In addition to the scientific goals, improvements, and innovations in the technological areas of cryogenics, gyroscope design, and precision clocks are expected. Specific objectives include the development and operation of a flight qualified cryogenic gyroscope; complete gyroscope system error analysis, and the consideration of various theoretical formulations of relativity and their subsequent experimental implications. Possible future benefits apart from the scientific ones include improved timing for navigation, communication, and geodesy as well as cryogenic systems capable of extended operation in space. These objectives are to be met by supporting programs involving technological development in masers, gyroscopes, and cryogenics to implement flight experi-

ments. Concurrently, theoretical work is promoted to expand the base needed for data interpretation.

W74-70624 **188-41-54**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
RELATIVITY AND CELESTIAL MECHANICS
Donald P. Burcham 213-354-3028

One task will explore consequences of those astrophysical observations and theoretical arguments which imply the existence of a hot intergalactic plasma, some 60 to 100 times denser than the matter visible in galaxies. To describe early phases of cosmological evolution, anisotropic big band world models will be formulated incorporating dense conducting plasmas and fields. Understanding of both the presently observed isotropy and composition of the universe, and of the time scales involved, will be sought in the large scale evolution of such models from chaotic initial conditions. Discussion of cluster and galaxy formation will require formulation of perturbation theoretic equations of inhomogeneous cosmologies, where the unperturbed equations are those of anisotropic models with dense plasmas and fields. The previously developed dyadic formulation of general relativistic cosmology will be used. An important astrophysical application of this work will be to evaluate the influence of cosmological electromagnetic fields on the evolution and present state of the intergalactic medium. Heating and cooling of an intergalactic plasma and the acceleration of high energy particles therein by such fields will be investigated to determine the effect on the composition, excitation, and ionization state of the medium as a function of time, and on the development of inhomogeneities in the medium. These studies are relevant to interpretation of ultraviolet observations of the intergalactic medium with the IUE and LST instruments. The other task provides for support of JPL personnel to follow and review the technical studies on the gravitational theories in space conducted by the European Space Research Organization (ESRO), and to provide liaison with that organization.

W74-70625 **188-41-55**
Goddard Inst. for Space Studies, New York.
MILLIMETER-WAVE AND FAR-INFRARED ASTRONOMY
Patrick Thaddeus 212-866-3618

The main scientific purpose is (1) to observe interstellar molecules at millimeter and submillimeter wavelengths, in order to study the dynamics of dense interstellar clouds, the process of star formation, isotopic ratios, interstellar chemistry, and other astrophysical topics; and (2) to obtain laboratory data on molecular spectra in order to interpret these observations, and in order to search for new molecules in space. The main technical purpose is to extend radio frequency techniques into the far infrared for use on aircraft and space vehicles.

W74-70626 **188-41-55**
National Aeronautics and Space Administration, Washington, D.C.
INFRARED ASTRONOMY
N. W. Boggess 202-755-3688

The objective is to advance stellar and galactic astronomy in the spectral region between 1 and 1000 microns through observational and theoretical programs. Observations in the infrared portion of the electromagnetic spectrum are particularly important for an understanding of the early and late stages in stellar evolution, installar matter, galaxies and quasi-stellar objects, and the energy mechanisms associated with them, and the residual radiation of the universe. A balanced program including observation, technique and instrumentation development, and theory is required to insure the advances needed for full utilization of future platforms in space. The approach includes the following elements: (1) the support of observational programs using ground-based telescopes, balloons, and airplane; (2) the development of infrared techniques and appar atus. Special emphasis is placed on far IR narrow band filters, spectral interferometers, modulation techniques, and multiple detector arrays in order to enhance the information content of an observation: and more recently, on development of cryogenic and low-background telescopes; and (3) the modification of existing instrumentation in order to optimize performance---

W74-70627 **188-41-55**
Lyndon B. Johnson Space Center, Houston, Tex.
ULTRAVIOLET STELLAR SPECTROMETER DEVELOPMENT
Y. Kondo 713-483-6467

The objective is to observe Mg II doublet emission at 2795 A and 2802 A in various spectral type stars. Particular emphasis will be placed in the intermediate to early type stars. (In this spectral region, the Ca II doublet emissions at 3933 A and 3968 A become unobservable.) Variability of the Mg II emission will also be investigated. The balloon-borne ultraviolet stellar spectrometer (BUSS) has been designed, fabricated, and flown successfully twice in 1971. Further flights will be required to extract the full usefulness of this instrumentation. The objectives for FY-74 are to further develop the inner loop pointing system of the balloon payload and also explore the feasibilities for adaptation of a multichannel detector system in order to enhance the observing capabilities of the BUSS. The study indicates this possibility to be promising. Near-infrared spectra of planetary nebulae, Wolf-Rayet stars, and cool stars are measured with a Michelson interferometer and the 107 in McDonald Observatory telescope. Analysis of the spectra yeilds information on the composition and structure of the nebular gases and stellar atmospheres.

W74-70628 **188-41-55**
Ames Research Center, Moffett Field, Calif.
INFRARED ASTRONOMY
Glen Goodwin 415-965-5065

The broad objectives of this program are: (1) to obtain and interpret astronomical data in the far infrared region of the spectrum, and (2) to develop and evaluate improved platforms and instrumentation for infrared astronomy. A 28 in. balloon-borne telescope has been modified for observing in the far infrared. Engineering test flights have verified that repeated launchings can be performed with turn-around times of only a few days. An offset tracking capability is being developed for the telescope to permit prolonged observations of infrared sources that do not have bright visible counterparts. Broad-band photometric observations are planned for early flights and spectroscopic data are expected for flights later in this program. Specific objectives include planets, HII regions, circumstellar dust clouds and extragalactic objects.

W74-70629 **188-41-55**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
INFRARED ASTRONOMY
Donald P. Burcham 213-354-3028
(196-41-72)

The objective of this task is to acquire and analyse high resolution stellar spectra at near infrared (1-6 microns) wavelengths. The principal instrumentation employed is a Connes'-type Fourier spectrometer operated at the coude' focus of the 107 in. telescope, McDonald Observatory. The program is undertaken with the active collaboration of the Astronomy Department of the University of Texas at Austin, the primary aim being to aid in the understanding of the composition, structure and evolutionary state of late-type stars and variables. A secondary objective is to provide back-up data and operational experience in order to participate fully in future LST and Shuttle Observatory missions.

W74-70630 **188-41-59**
Goddard Space Flight Center, Greenbelt, Md.
X-RAY ASTRONOMY
Elihu A. Boldt 301-982-5853

X-ray production is a necessary consequence of energetic charged particles in space. Relativistic electrons radiate X-rays characteristic of their interactions with magnetic fields, ambient electromagnetic waves and interstellar grains. Subrelativistic suprathermal charged particles, including cosmic ray nuclei as well as electrons, generate X-rays characteristic of collisions with ambient gas (e.g. bremsstrahlung continuum radiation and characteristic line emission resulting from electron charge exchange between highly stripped nuclei and ambient atoms). Hot plasmas generate X-rays characteristic of thermal electron-ion interactions. Hence, by studying the X-ray emission from stellar objects, nebulae, the interstellar medium and extragalactic space

we get direct information on energetic processes over a broad range of physical conditions and astronomical scales. Observations of hard X-rays are made with mechanically collimated proportional counters of advanced design. The technical goals are large effective area, broad spectral coverage, optimum resolution, and efficient rejection of extraneous events (e.g., caused by gamma rays, electrons, radioactivity). These goals, coupled with a detailed knowledge of detector response, are being achieved via laboratory tests, balloon and rocket flights. Observations of soft X-rays may be made with small specialized detectors at the focus of grazing incidence optics. Cooled solid state detectors and gas X-ray filters are being investigated.

W74-70631 **188-41-59**
National Aeronautics and Space Administration, Washington, D.C.
X-RAY ASTRONOMY
N. G. Roman 202-755-3649

The objective is to investigate and understand the nature of sources of X-ray emission. The number of such sources detected has been increasing by virtue of the active observational program being conducted with balloons, rockets, and satellites. As experimental techniques have been refined, a number of point sources have been identified with unusual optical objects both galactic and extragalactic in origin. In addition, X-ray variability of different characteristic forms has been found; some sources are analogous to the radio and optical pulsars. The general cosmic X-ray background, as well as the point sources need further study in order to elucidate the emission mechanism and the cosmological significance of these objects. Specific objectives are the detection of additional sources, spatial mapping of the background, accurate positional determination and correlation with optically identifiable objects. These objectives are met by supporting laboratory studies, flight programs, and theoretical work. Research and development of advanced detectors, shielding systems and focusing optical systems are being conducted. Data processing methods are being refined.

W74-70632 **188-41-62**
Goddard Inst. for Space Studies, New York.
VIDICON OBSERVATION OF FAINT GALAXIES AND QUASI-STELLAR OBJECTS
H. Y. Chiu 212-866-3622

The objective is to use an SEC vidicon system to: (1) study the outer regions of Seyferts and other faint galaxies; (2) search for galactic features surrounding quasars; (3) search for direct evidence of intergalactic matter. A vidicon system using an SEC tube has been constructed and successfully tested at Kitt Peak. The noise level is below 10 photo-electrons per picture element and the sky light reaches 1/2 saturation level in about 3 minutes, as expected. A system of computer processing of images from vidicons is under development. In the coming year it is planned to do large-scale data collection (about 1000 images per object) and to stack these images in the computer. This stacking will reduce the noise level by a factor of N where N is the number of images stacked. Theoretically when N = 1000, we can recognize images which are approximately 30 or 3 magnitudes fainter than the sky background. In practice, judging from work with photographic emulsions, an improvement of approximately 2 magnitudes can be realized.

W74-70633 **188-41-63**
Goddard Inst. for Space Studies, New York.
THEORETICAL STUDIES ON NEUTRON STARS AND GRAVITATIONAL WAVES
V. M. Canuto 212-866-3200

The objective is to study mechanisms for emission of gravitational radiation. The primary aim of the investigation is to calculate sudden structural changes and oscillations in the quasi-solid core of a neutron star or pulsar, with the view that these oscillations can be sources of intense gravitational radiation, and to calculate intensity and polarization of the resultant gravitational waves.

W74-70634 **188-41-64**
Goddard Space Flight Center, Greenbelt, Md.
ASTRONOMY SORTIE INSTRUMENTS
T. P. Stecher 301-982-4718

The object of this RTOP is to define and implement a group of astronomical experiments to be performed by using the space shuttle in a sortie mode. The specific goals are the definition of the scientific objectives, formulation of instrumentation requirements, establishment of operational criteria and modes, and formulation of data acquisition and reduction procedures. The wavelength region to be covered will be from the far ultraviolet to the near infrared (100 A to 5 microns). The approach will be to convert the sounding rocket technique to shuttle use through the use of instruments that will operate on the shuttle on a non-interference basis and can also be flown in rockets prior to shuttle availability. In order to take full advantage of the shuttle as a vehicle for launching sounding rocket type payloads, these payloads should not be restricted by any shuttle environmental factors nor should they impose any particularly difficult restriction on the shuttle. The shuttle vibration environment imposes no restriction in the face of much more severe survival levels required for sounding rocket operations. The long duration vacuum environment is known from present spacecraft technology, and is not a major problem area.

W74-70635 **188-41-64**
Goddard Space Flight Center, Greenbelt, Md.
X-RAY SPECTROSCOPY FOR SHUTTLE
Elihu A. Boldt 301-982-5853
(188-41-59)

X-ray production is a necessary consequence of energetic charged particles in space. Relativistic electrons radiate X-rays characteristic of their interactions with magnetic fields, ambient electromagnetic waves, and interstellar grains. Subrelativistic suprathermal charged particles, including cosmic ray nuclei as well as electrons, generate X-rays characteristic of collisions with ambient gas (e.g. bremsstrahlung continuum radiation and characteristic line emission resulting from electron charge exchange between highly stripped nuclei and ambient atoms). Hot plasmas generate X-rays characteristic of thermal electron-ion interactions. Hence, by studying the X-ray emission from stellar objects, nebulae, the interstellar medium and extragalactic space direct information is obtained on energetic processes over a broad range of physical conditions and astronomical scales. A large array of cooled solid state detectors (Ge and Si) provides the optimum spectral resolution available over a broad band (approximately 0.5 keV to tens of kilovolts) that effectively covers the entire continuum spectrum for a wide class of sources. At lower energies, photoelectric detectors with gas filters provide a potentially sensitive means of identifying line emission.

W74-70636 **188-45-51**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
COMETS AND ASTEROIDS
Donald P. Burcham 213-354-3028

Asteroids, meteorites, and fireballs are all small bodies in the solar system. The long term evolution of their orbits under gravitational forces can be studied with the same computer programs. The intent is to study the origin and evolution of all three classes of small bodies in a uniform manner. The objectives are: (1) To determine whether meteorites and fireballs can come from the asteroid belt using secular resonances. If so what asteroids are the likely parent bodies? (2) Update the asteroid belt and family study as new asteroid data becomes available. Do special studies of families where useful. (3) Investigate the long-term orbital evolution of special objects by numerical integration. (4) Publish the existing theory of secular perturbations which has been used in calculating proper elements.

W74-70637 **188-45-51**
National Aeronautics and Space Administration, Washington, D.C.
COMETS AND ASTEROIDS
Maurice Dubin 202-962-2847
(188-45-52; 188-45-53)

The objectives are to investigate the origin, structure, and physical nature of comets, asteroids, the zodiacal light, and gegenschein. The objectives include: (1) study of the comets,

asteroids, zodiacal light, and the gegenschein, in relation to the origin and evolution of the solar system; (2) determination of the physical and chemical properties of the ensembles of gases and plasmas and microparticles in space; (3) determination of dynamical properties of interplanetary bodies in the solar environment, especially the evolutionary properties of comas and tails of comets; (4) investigations of the component of the interplanetary dust of interstellar origin and its properties; and (5) application of these investigations to interplanetary missions involving comet and asteroid intercepts, rendezvous, and simple return. Astronomical observations will be made of the comets, asteroids, zodiacal light, and gegenschein to determine the morphology, spectral characteristics, polarization, and evolutionary properties. The observations involve both ground based observations and observations from aircraft and balloons. The chemical and physical nature of ensembles of gases, plasmas, and microparticles is studied in the laboratory and in space, and by releases in space of clouds of gases, plasmas, and small dust particles.

W74-70638 **188-45-51**
Marshall Space Flight Center, Huntsville, Ala.
COMETS AND ASTEROIDS
G. A. Gary 205-453-3103

The objective is to test and observe with the available photoelectric detector package and data acquisition system in order to establish the nature of the interstellar medium. The polarimeter would be used in support of determining the correlation between ground-based and space observations from OSO, LST, and Skylab.

W74-70639 **188-45-51**
Goddard Space Flight Center, Greenbelt, Md.
COMETS AND INTERSTELLAR MATTER
B. D. Donn 301-982-5014

This RTOP includes several programs to study interplanetary and interstellar matter. The primary objective is the performance of laboratory experiments to obtain the basic physico-chemical characteristics of molecules and solid grains. These species are chosen because of their known or expected occurrence in space. Theoretical analysis of astronomical problems using this data is a second aim. A third aspect involves flight observations to obtain new data. The last phase uses ground based telescopic observations. Molecular beam and laser techniques are being used for measuring production of atoms, radicals and ions from planetary, cometary or interstellar molecules by impact of photons, electrons or ions. The optics, spectroscopy and grains will be investigated. The possible relation of cometary and interstellar molecules to chemical evolution and the origin of life will be examined. In support of other research, use of image intensifiers to study comets and interplanetary matter will be investigated.

W74-70640 **188-45-52**
National Aeronautics and Space Administration, Washington, D.C.
METEOR ASTRONOMY
Maurice Dubin 202-755-3685
(188-45-51; 188-45-53)

The objectives of the meteor astronomy research include determination of the characteristics, composition, and population distribution of meteoroids, in addition to studies of the physical reactions of meteoroids in the atmosphere, contributions to the structure of the atmosphere, and the entry ballistics of a body into a planetary atmosphere. Meteor astronomy is the observational study of solid bodies and meteoroids in the solar system from the action during the entry into the earth's atmosphere. From these observations the meteors' track, the velocity, the spectroscopic characteristics, the orbits, the population distribution, mass distribution, structure, and composition may be determined. The observational methods include photographic and image intensifier observations of meteors, including use of spectrographic equipment and observations with radar and lasers. The research on meteors is concentrated on the extremes of a meteor magnitude scale, the very bright meteors with masses of a few kilograms to tons, and the minute particles observed with radar and laser beams. The observations of the interactions of the bright meteors with the atmosphere give structural information and composition from spectroscopic observation. In some cases the bright meteors are the source of the recovery of cosmic dust particles by searching the impact region or by capture, using aircraft collection systems, shortly after a fireball passage.

W74-70641 **188-45-52**
Langley Research Center, Langley Station, Va.
METEOR ASTRONOMY - OBSERVATION, SPECTRAL AND DATA ANALYSIS
Eugene S. Love 703-827-2893

The primary objective of the in-house research is to continue to obtain spectra of shower meteors; and to obtain spectra and velocity, altitude, and orbit data of sporadic meteors. Radiation studies using shock-excited meteorite spectra and other radiation data will be conducted. Studies of earth orbital, far UV meteor spectroscopy of silicon, carbon, magnesium, and hydrogen will be made. An engineering model of a far UV meteor photometer will be developed. Airborne meteor observations will be made. Data reduction and analysis with emphasis on elemental abundance determinations will continue at LaRC. The objectives of the contract (SAO) meteor research are: to reduce radar meteor data collected over the period 1965 to 1968; to finish reductions and analysis of simultaneous meteor data; and to analyze this meteor data in order to reduce basic uncertainties in flux, mass, composition, density, and ablation of meteoroids that enter the earth's atmosphere. Additional objectives of the SAO meteor research are to determine orbital distributions of sporadic meteors and meteor streams within the meteor sample, and to investigate associations of meteor streams with comets and asteroids. The research will be accomplished by upgrading and further automating the two-station direct-photography meteor camera system and slitless spectrographs. A two-station meteor observing program in the Southwest USA during the period October 1973 through May 1974 will be established. Statistical studies of data in hand (in collaboration with Dr. Peter Millman) and detailed reduction of---

W74-70642 **188-45-52**
Marshall Space Flight Center, Huntsville, Ala.
METEOR ASTRONOMY
K. S. Clifton 205-453-0942

Low light level television systems onboard airborne expeditions can be used to make optical, real-time, examinations of faint phenomena under the improved atmospheric conditions encountered at high altitudes. Data recorded by secondary electron conduction (SEC) video cameras can provide on-the-spot support to other experiments and can be filmed or stored on video tape for analysis. Special filters allow examination to be made in selected spectral regions. Thus astronomical events (aurora, eclipses, etc.) occurring at times and places for which no real-time observations are available, may be analyzed in the laboratory. Low light level television (SEC vidicon) systems equipped with full aperture diffraction gratings will be used to obtain spectrophotometric data on meteors. Analysis of the data will be done by using: (1) photography of the TV screen, (2) use of video analysis on stop action frames of TV, and (3) use of moving target video processors to isolate the moving spectra from a stationary background, a scan converter for storing the spectra, and autocorrelation to identify faint spectral lines. An imaging device will be interfaced with a minicomputer making it ideally suited for image processing application. The system will make an ideal meteor comet or asteroid telescope for both ground based or spacecraft observations.

W74-70643 **188-45-53**
Ames Research Center, Moffett Field, Calif.
COSMIC DUST MEASUREMENTS
Glen Goodwin 415-965-5065
(385-45-01; 879-10-00)

The objective is to perform chemical analyses of extraterrestrial material (involving major element, trace element, and isotopic determinations) enabling interpretation of the nature and origin of cosmic dust and meteorites. A laser microprobe will be used in this work to excite spectral emission from cosmic dust grains,

pollution particles, and meteorite minerals as a means of studying major and trace element content. Laser-mass spectrometer and electron probe techniques will also be applied to determine isotope ratios, structural chemistry, and major element contents of terrestrial and exterrestrial material, and pollution particles. A direct-reading probe (one using photomultiplier tubes) is in operation and is proving to be a sensitive and precise method for trace element study. Laser power output is now being monitored to improve reproducibility. A laser-to-mass spectrograph linkup is also in process of construction. This will allow identification of radical groups and isotope ratios in unknown particles.

W74-70644 **188-45-53**
National Aeronautics and Space Administration, Washington, D.C.
COSMIC DUST RESEARCH
Maurice Dubin 202-755-3685
(188-45-51; 188-45-52)

The objective of this research is the understanding of the nature and origin of condensed matter in the solar system. This cosmic dust research area involves: (1) detection and collection of material of cosmological significance; (2) analysis of cosmic dust material for structure, composition and isotope, distribution; (3) development of instruments and techniques for collections and analysis. The design of instruments for flight on probes and satellites, and the design of collection systems is included in this research. These collection systems are often carried on balloon and aircraft, with aircraft being of special use in collections following the passage of a fireball. The detailed analysis of the composition is related to observations of comets, asteroids, meteors, and the composition of solar nebula. The identification of the volatile component, the existence of complex organic molecules, an interstellar signature, and any connection to biogenic evolution are important elements of the analysis. The analysis includes the use of electron and stereoscan microscopy X-ray diffraction, isotopic analysis, and mineralogical-petrographic microprobes.

W74-70645 **188-45-53**
Goddard Space Flight Center, Greenbelt, Md.
COSMIC DUST RESEARCH
Charles C. Schnetzler 301-982-2283

The objective of this research will be to understand the nature and history of condensed matter in the solar system. The multidisciplinary approach will involve the analyses of meteorites by the following techniques: (1) chemical analyses - major, minor and trace element composition by conventional 'wet' chemistry, X-ray fluorescence and high precision atomic absorption; (2) nondestructive gamma-ray analyses naturally-occurring K, U and Th, and cosmic ray-produced radionuclides (such as Al) by low-background gamma-gamma coincidence spectrometry; (3) major, minor and trace element analyses in individual mineral grains and grain boundaries by electron microprobe, and ion microprobe microanalyzer; (4) cosmic ray and fission track analyses by track etching techniques; and (5) mineralogical and petrographic analyses.

W74-70646 **188-46-56**
National Aeronautics and Space Administration, Washington, D.C.
PARTICLE ASTROPHYSICS
Albert G. Opp 202-755-2689
(188-46-51; 188-46-52)

The objective of this RTOP is to study the isotopic and charge composition and energy of galactic and solar cosmic rays. The primary galactic radiation represents the direct penetration of material from the galaxy into the solar system. The study of the nuclear composition and energy of this material provides direct evidence of the stellar processes responsible for the cosmic radiation and information on the interstellar material transited by the cosmic radiation. The observation of solar cosmic rays provides information on the abundances of different elements in the sun and information on the solar processes that accelerate energetic particles to their observed energies. The design, construction and test of cosmic ray detectors is the prime activity supported by this RTOP. Solid state detectors, magnetic spectrometers, scintillators, Cerenkov counters and ionization spectrometers are typical instruments developed and tested under the support of this RTOP. Research balloons are employed extensively in high energy astrophysics. Balloon flights are used both to test new instruments and to obtain new scientific information on the properties of cosmic radiation. New instrument concepts are also tested at particle accelerations and from mountain top laboratories.

W74-70647 **188-46-56**
Goddard Space Flight Center, Greenbelt, Md.
PARTICLE ASTROPHYSICS
F. B. McDonald 301-982-4801
(188-46-64)

The objective is to measure the energy spectra, charge and isotopic composition of the primary cosmic radiation and of solar cosmic rays. Supporting this objective is the development of new detector systems for the study of the properties of cosmic radiation, and the associated development of theoretical studies related to these experiments. The results will be used in astrophysical considerations concerning the origin, acceleration and propagation of cosmic radiation. Specific goals are enumerated as follows: (1) measurements of the high energy composition of the cosmic radiation, including spectral, charge and isotopic studies from electrons up through the heaviest elements; (2) development of detectors to study the low energy composition of solar and galactic cosmic rays, with the goal of measuring the intensity of cosmic rays at great distances from the sun on deep space missions; and (3) improved measurements of the positron ratio from 20 MeV to 20 GeV. Detectors will be designed, constructed, and tested in our laboratories. Detector behavior will be explored using particle accelerator beams and other devices. Balloon flights will be carried out both for the purpose of detector development and for obtaining new scientific information. New measurements will be made of the properties of cosmic radiation available for study at balloon altitudes.

W74-70648 **188-46-57**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
GAMMA RAY ASTRONOMY
Donald P. Burcham 213-354-3028

This describes the JPL part of a cooperative program with UCSD in X- and gamma-ray astronomy. The objective is to observe line spectra in extraterrestrial X-ray and gamma-ray sources in the 0.05 to 10 MeV energy range. Observation of such sources would provide important information on nucleosynthesis, galactic history and the nature of cosmic X-ray sources. Under this program, a gamma ray sensor which has been developed for lunar missions will be adapted to balloon flight systems for carrying out astronomical observations while simultaneously studying their properties and performance in a space-like radiation environment. The specific objective for this program for FY-74 is to integrate an advanced solid state detector array, its cesium iodide shield, pulse-height analyzer, and data handling electronics into a balloon-flight system and perform a balloon flight in the last part of FY-74.

W74-70649 **188-46-57**
National Aeronautics and Space Administration, Washington, D.C.
GAMMA RAY ASTRONOMY
Albert G. Opp 202-755-3689
(188-46-64)

The objective of this RTOP is to measure the characteristics of energetic photon emission from celestial sources and to understand the physical processed responsible for the emissions. This RTOP includes photonic radiation from approximately 10 keV in energy upward to as high as can be measured, that is, from hard X-rays to ultrahigh energy gamma rays. Several hard X-ray sources have been identified, which have spectra extending into the tens to hundreds of keV. The spectra of discrete sources and the spectra and distribution of the diffuse background will provide information on the physical processes active in stars, galaxies and interstellar space. Gamma ray photons result from a number of physical processes (see Item 14). These processes can furnish information on the synthesis and

distribution of elements in the universe, on the magnetoplasma environment of a star, on the condensation and interaction of interstellar material with radiation, as well as other astrophysically important parameters. Gamma rays, which are undeflected by magnetic fields, travel directly from their sources, and anisotropies in the direction of arrival of the photons gives information on the location of the gamma ray sources.

W74-70650 **188-46-57**
Goddard Space Flight Center, Greenbelt, Md.
GAMMA RAY ASTRONOMY
C. E. Fichtel 301-982-6281
(188-46-54)

The technical objective is to develop the most appropriate detector systems for the observation of the astrophysical sources of very energetic photons. The approach has been divided into several different parts. The first approach to the general problem of gamma-ray astronomy was the development of a large telescope using digitized spark chambers to be tested on high altitude balloons and then flown on satellites. Other approaches to detector systems are now being purchased both for the high energy gamma rays and intermediate gamma ray studies. A medium energy gamma ray detector has been designed and built. A unique feature of this system is its high time resolution which will permit the tagging of several gamma rays during a short (microseconds) pulse as might be expected from a supernova outburst. Improvements in the spark chamber systems are continuing, and methods for accurate timing are being developed for a search for discrete source emission of gamma rays at pulsar preiodicities. Special attention in the digitized chamber research is now being directed at designing and building low cost chamber of significantly larger size. In addition, a complementary ground-based detector system is being operated to search for atmospheric fluorescence which would be generated by photon pulses. These pulses are expected to result from extra-galactic supernova, and their detection would strongly suggest that supernova are the principal sources of cosmic ray particles.

W74-70651 **188-46-64**
National Aeronautics and Space Administration, Washington, D.C.
ASTROPHYSICAL INVESTIGATIONS ON THE SPACE SHUTTLE
Albert G. Opp 202-755-3698
(188-64-56; 188-46-57)

The space shuttle represents the next major development of a flight opportunity in high energy astrophysics beyond HEAO. The concepts and parameters for the next generation of spacecraft instrumentation have begun to evolve from the space shuttle working group. Most of the instrumentation exists in conceptual form only. In order to assure that the instruments are developed and tested on a time scale commensurate with the flight schedules of the shuttle, it is necessary to begin at this time the support of several investigators who are interested in carrying out such investigations on the shuttle. The funds provided under this RTOP will support the development of very high energy charged particle detectors, large gamma ray detectors and the study of discipline unique requirements, which might be placed on a shuttle facility.

W74-70652 **188-46-64**
Goddard Space Flight Center, Greenbelt, Md.
SHUTTLE DEFINITION STUDIES FOR HIGH ENERGY ASTROPHYSICS
F. B. McDonald 301-982-4801

The objective of this program is to develop a variety of new detector systems for high energy astrophysics research, including cosmic-ray, X-ray and gamma ray astronomy. Meaningful new experiments in these fields presently require the development of several new devices, incorporating new improvements in energy, charge and isotope resolution, in temporal resolution and directional resolution, and utilizing very large payloads of great size and weight, capable of orbit with the shuttle. The technical objective is to measure the energy distribution and the charge and mass composition of the several components of the primary cosmic radiation. These components include both electrons and nuclei from hydrogen to iron, lead, uranium, and beyond. Beyond 1012 eV, information is presently available, primarily because particles in this range are very rare. The spectra fall steeply with increasing energy requiring large area detectors and long exposure times. This large exposure must be obained while maintaining the resolution of much smaller detectors. Energy measurements in this highly relativistic range are currently being done using ionization spectrometers. Development of new techniques such as transition radiation detectors, large area gas filled counters, magnetic spectrometers, etc. will be required to extend existing measurements to beyond a TeV/nucleon. The properties of charge measuring devices, direction detecting devices; and total ionization spectrometers will be calibrated on---

W74-70653 **188-48-51**
Marshall Space Flight Center, Huntsville, Ala.
INTERDISCIPLINARY SPACE RESEARCH
E. Stuhlinger 205-453-3033

The objective is to conduct space research in various scientific and technical disciplines with a capability of directing quick reaction efforts towards significant problems or promising areas of research and with the overall purpose of enhancing in-house scientific capabilities of the MSFC. Under the direction of the Associate Director for Science, Dr. Ernst Stuhlinger, research is initiated in scientific and technical areas which influence the scientific missions of the Center. Research projects are selected which, within available resources, contribute significantly to in-house scientific capabilities and state-of-the-art advancement. These projects are then funded from the Interdisciplinary Space Research discretionary funds.

W74-70654 **188-48-52**
Goddard Space Flight Center, Greenbelt, Md.
BASIC THEORETICAL RESEARCH
Aaron Temkin 301-982-5213

The objective is to develop techniques for the solution of basic (prototype) atomic collision problems involved in processes occurring in planetary and stellar atmospheres, and in other plasmas: also for collision processes that may be used as diagnostic tools in atmospheres. Specific work implementing the above objective fall in the following general categories: (1) study of electron impact ionization; (2) development of techniques and calculations of autoionization states of atomic systems; (3) calculation of electron molecule scattering techniques; (4) study of positron-atom scattering and reactions; (5) study of electron-atom scattering methods; (6) investigation of hydrogen-antihydrogen annihilation and its cosmic significance; and (7) study of photoionization processes.

W74-70655 **188-78-51**
Marshall Space Flight Center, Huntsville, Ala.
LOW GRAVITY SUPERFLUID HELIUM ADVANCED TECHNOLOGY DEVELOPMENT
R. A. Potter 205-453-3432

Several experiments are currently being developed which will require a low temperature environment for their proper operation in space. Superfluid helium will undoubtedly be used for many of these applications. Immediate applications to experiments are to be found in cosmic ray, relativity, and infrared astronomy. The purpose of this task is to investigate theoretically and experimentally, where possible, the properties of superfluid helium to be expected when liquid helium dewars are flown into space. The properties of superfluid helium in this near zero gravity environment will be assessed and methods will be investigated whereby problem areas may be resolved or controlled.

W74-70656 **188-78-51**
Goddard Space Flight Center, Greenbelt, Md.
ADVANCED TECHNOLOGICAL DEVELOPMENT, GENERAL: ON-BOARD PROCESSING ELECTRONICS; SOLID STATE NUCLEAR DETECTORS
J. H. Trainor 301-982-6282

The technical objectives of this research project are to develop and test new on-board signal handling, data processing, storage, computing and auxilliary electronics circuitry for use in energetic particle and astrophysics experiments on Pioneer, HEAO, Helios,

Shuttle missions, Explorers, outer planet missions, rockets, balloons, etc., as well as special test and analysis equipment applicable for both ground and shuttle usage. The growing complexity of experiments and the often corresponding increase in volume of data obtained have made signal handling, data processing and data transmission - capability limiting factors. To reduce the transmission of unnecessary data, it is necessary to increase the experiment's on-board signal handling and data processing capability. This program is approached through: (1) the investigation and development of new techniques for signal shaping and handling, data processing and auxiliary circuitry, and (2) the modification of existing techniques by the application of advanced technology and materials including bipolar integrated circuits, MOS/LSI technology, thick film techniques, micropower circuitry and multiple chip techniques. Special techniques must also be devised in order to accurately and efficiently evaluate and test the flight systems at low cost. Some of these techniques using minicomputers will also apply to flight use for shuttle experiments. The technical objective of the research project is to conduct a program of research and development, and device test and evaluation in the field of silicon nuclear radiation detectors with emphasis on (1) the improvement of detector technology; (2) the understanding of the radiation damage effects on device operation and lifetime; (3) the understanding of the effects on these detectors of chemicals commonly used near or on ---

W74-70657 **188-78-51**
National Aeronautics and Space Administration, Washington, D.C.
ADVANCED TECHNOLOGICAL DEVELOPMENT, GENERAL; CRYOGENICS
M. J. Aucremanne 202-755-3676

Physics and astronomy experiments are being developed which will require a low temperature environment for their proper operation in space. Superfluid helium will undoubtedly be used for many of these applications. The purpose of this work is to investigate theoretically and experimentally, where possible, the properties of superfluid helium to be expected when liquid helium dewars are flown in space. Properties of superfluid helium and other cryogens for application in IR astronomy, cosmic ray physics and relativity will be assessed and methods to deal with problems will be developed.

W74-70658 **188-78-56**
Goddard Space Flight Center, Greenbelt, Md.
DESIGN, ANALYSIS, AND EVALUATION OF THE LARGE SPACE TELESCOPE OPTICAL INSTRUMENT SYSTEM
A. B. Underhill 301-982-5101
(502-23-54; 975-84-78)

The Large Space Telescope (LST) is intended as a very high performance multipurpose astronomical research facility. Candidate instruments for the LST include the full gamut of imaging, dispersive, photometric, polarimetric, and interferometric devices, and the fine guidance system necessary to properly point the telescope. The various instruments will be designed to operate in specific wavelength regions extending from the Lyman limit through the near infrared; they will be removable for service and, in some cases, interchangeable so that the flight complement of instruments can be modified in orbit to reflect improvements in the state of the art or changes in programmatic emphasis. Three types of activity will be supported under this plan: (1) development and evaluation of novel devices potentially applicable to LST instruments; (2) definition and detailed design of specific scientific instruments to meet the performance objectives of LST; and (3) development of the data handling and data reduction techniques that will be required in order achieve to the full research potential of the instrumentation. Items (2) and (3) are closely interactive and should proceed together.

W74-70659 **188-78-56**
Marshall Space Flight Center, Huntsville, Ala.
SCIENTIFIC INSTRUMENT DEVELOPMENT FOR THE LARGE SPACE TELESCOPE
C. R. ODell 205-453-0162

The long range goal of the LST project is to build and operate a large, diffraction limited optical telescope, exploiting the capability for detection of faint sources, high angular resolution studies of all sources, and measurement over a wide wavelength range. The broadest expertise in astronomical instrument design and consequently the best definition of instrument needs lies with the body of ultimate users, the astronomical community, which must be brought into LST activity. This will be done through two means, a two-body (Instrument Definition Team and LST Working Group) organization developing scientific instrument definitions and identifying science and engineering tradeoffs between potential instruments and through contracts to develop supporting technology based on the recommendations of the Instrument Definition Teams (IDT) and the LST Working Group (WG). Contracts will be let by MSFC to Members at Large of the LST Working Group and by GSFC to members of the Instrument Definition Teams. Contracts for supporting technology will be let by GSFC.

W74-70660 **188-78-56**
National Aeronautics and Space Administration, Washington, D.C.
OPTICAL INSTRUMENTATION - IMAGE TUBE DEVELOPMENT
M. J. Aucremanne 202-755-3676

Development of the Large Space Telescope is fundamental to the objectives of the Astronomy Research Program. It is essential that normal incidence image forming systems operating with maximum spatial and spectral resolution in the IR, visible, and ultraviolet regions be evolved. These instruments will be required to detect and present astronomical data in extreme fidelity. In order to accomplish this it will be necessary to develop a series of instruments that both accomplish their scientific objective, and at the same time provide technological data to permit a burgeoning capability. In order to fully utilize such advanced telescopes it will be necessary to concurrently develop suitable electronic image sensing systems.

W74-70661 **188-78-57**
Marshall Space Flight Center, Huntsville, Ala.
LARGE SPACE TELESCOPE ADVANCED TECHNOLOGY
Garvin R. Emanuel 205-453-3427
(188-78-58)

The objective of the LST Project is to orbit a large, high resolution optical telescope system which is international in scientific usefulness and which will significantly extend man's knowledge of the universe. The immediate objective is to fulfill as many of the scientific and technological requirements as possible during the mission that will provide mankind with astronomical analysis beyond the reach of all ground-based telescopes and, simultaneously, provide scientific, technological, and operational knowledge for the obtaining of diffraction-limited performance in the early 1980's. The projects outlined in this RTOP are necessary to solve the technological problems associated with the design and development of the LST.

W74-70662 **188-78-58**
Marshall Space Flight Center, Huntsville, Ala.
LARGE SPACE TELESCOPE PHASE-B STUDIES
James A. Downey 205-453-2039

The objective of the LST project is to orbit a large, high resolution optical telescope system which is international in scientific usefulness, which will significantly extend man's knowledge of the universe, and which will provide mankind with astronomical analysis beyond the reach of all ground-based telescopes. The objective of the Phase-B effort is to obtain sufficient information on each alternate LST project approach resulting from the Phase-A study to permit the recommendation of a single approach for LST. Further, it is to provide management with a basis for action on recommendations for follow-on project activity. Two prime contractors will be selected to conduct parallel eighteen-month studies, each funded at 800K. The contractors will define the Optical Telescope Assembly (OTA) and Scientific Instrument (SI) for the LST and prepare inputs for the LST Phase-C/D.

W74-70663 **192-55-61**
Ames Research Center, Moffett Field, Calif.
CHEMICAL EVOLUTION
H. P. Klein 415-965-5094
(192-55-62)

Chemical evolution encompasses the study of the evolutionary path of carbon and its compounds from the primal fireball, through interstellar dust clouds, to formation of galaxies, solar systems, and planets, to the first stirrings of life in the earth's primitive oceans. In the laboratory, the syntheses of organic compounds related to terrestrial biochemicals are explored in experiments which simulate the putative environments of interstellar dust clouds, cooling solar nebulae and primordial and extant planetary atmospheres and surfaces. The study is relevant to understanding the prebiological chemistry of the solar system which led in the case of earth to the formation of organic compounds and the origin of life, but which on extraterrestrial bodies and environments may have taken divergent paths. The study provides an experimental basis for the hypothesis that the origin of life on earth, and possibly elsewhere, was preceded by a period of organic chemical evolution in which simple compounds containing the organogenic elements C, N, O, S, P, H, were converted by abiotic processes into the complex organic molecules which are direct precursors of the macromolecules essential to life.

W74-70664 **192-55-61**
National Aeronautics and Space Administration, Washington, D.C.
PLANETARY BIOLOGY
R. S. Young 202-755-3732
(192-55-62)

Chemical evolution is the laboratory study of the nonbiological synthesis of biologically significant organic molecules under conditions presumed to have existed on the primitive earth or any primitive planet before the event of life. The study is relevant to understanding the origin and evolution of life. Experiments relevant to prebiological organic chemistry can in principal explain the processes by which primitive cells could have originated on the earth. The greatest of evolutionary puzzles, the origin of life, takes on a new immediacy in light of recent laboratory advances and experiments which have a different approach but have the same common denominator, i.e., pathways by which biologically significant molecules arose prior to life.

W74-70665 **192-55-62**
Ames Research Center, Moffett Field, Calif.
ORGANIC GEOCHEMISTRY
H. P. Klein 415-965-5094
(192-55-61)

The principles and practices of organic geochemistry can be applied in any cosmological study wherein a solid matrix is investigated for the presence or absence of organic compounds. Thus not only are geological materials from earth candidates for study, but also included in organic geochemical investigations are extraterrestrial samples such as meteorites and lunar materials. The main focus of organic geochemistry here is to study the occurrence, distribution and fate of organic compounds in terrestrial substances such as contemporary environments, recent and ancient sediments (including Precambrian rocks), and fossils. The methods and results of these studies are applied to the interpretation of the significance of organic substances in extraterrestrial materials. By using the earth and its geochemical processes as a model, information about extraterrestrial processes can be better interpreted. Highly refined analytical techniques are used in organic geochemistry to separate organic compounds from mineral matrices. These compounds form the basis for understanding geochemical processes including diagenesis. From these studies chemical criteria can be developed to distinguish between organic matter of biological and nonbiological origin. These criteria are essential for understanding the mode of origin of extraterrestrial organic materials.

W74-70666 **192-55-62**
National Aeronautics and Space Administration, Washington, D.C.
PLANETARY BIOLOGY
R. S. Young 202-755-3732
(192-55-61)

Organic geochemistry is the study of ancient terrestrial rocks for organic molecules and inclusions of biological origin. The development of techniques for the isolation of organic matter and distinguishing organic matter of biological origin from that of nonbiological origin. The applications of such technology to returned extraterrestrial samples.

W74-70667 **192-55-63**
Ames Research Center, Moffett Field, Calif.
LIFE DETECTION
H. P. Klein 415-965-5094
(192-55-66)

Those attributes of life which can be used for the remote detection of life are being studied. Techniques are being developed for the detection of active extraterrestrial life, for the detection of organic molecules unequivocally related to life, and for the determination of the nature of extraterrestrial life.

W74-70668 **192-55-63**
National Aeronautics and Space Administration, Washington, D.C.
PLANETARY BIOLOGY
R. S. Young 202-755-3732

The objectives are to develop techniques for the detection of extraterrestrial life and life related molecules, including evidence of life, past, present or future through the search for organic molecules of biological or nonbiological origin, metabolic activity, growth and reproduction, and visual identification.

W74-70669 **192-55-64**
National Aeronautics and Space Administration, Washington, D.C.
PLANETARY BIOLOGY
R. S. Young 202-755-3732

The study of the ability of microorganisms to survive and/or grow in environmental extremes approaching those of the planetary environments, particularly in terms of temperature and pH extremes, water availability, and salt concentrations. This is relevant to an understanding of biological processes in environments very different from those usually considered as being typical of the earth.

W74-70670 **192-55-65**
National Aeronautics and Space Administration, Washington, D.C.
BIONISTRUMENTATION
R. S. Young 202-755-3732

The broad objective of the effort is to develop instrumentation and techniques for planetary exploration in the field of exobiology. The primary emphasis of the program is directed at the exploration of Mars, but consideration will be given to application of the instrumentation to other planets. The work ranges from the continued development of a complex wet-chemical processor for the isolation and identification of soil compound such as amino acids, to feasibility studies and experiments involving the in-situ study of soil gas evolution, microscopy, and calorimetry, and gas chromatography-mass spectrometry. The approach will be to (1) develop, fabricate, and test in breadboard form specific critical components of the wet-chemical processor; (2) establish feasibility and perform preliminary design of in-situ gas exchange experiment; and (3) establish feasibility and perform preliminary design studies of remotely operated miscroscope systems; and (4) deterime feasibility of combining GC-MS with wet-chemical analytical systems.

W74-70671 **192-55-65**
Ames Research Center, Moffett Field, Calif.
BIOINSTRUMENTATION
J. V. Foster 415-965-5083

The broad objective of the effort is to develop instrumentation and techniques for planetary exploration in the field of exobiology. The primary emphasis of the program is directed at the exploration of Mars, but consideration will be given to application of the instrumentation to other planets. The work ranges from the

continued development of a complex wet-chemical processor for the isolation and identification of soil compound such as amino acids to development of a unified system for Mars life detection utilizing mass spectrometry. The approach will be to continue development and breadborad testing of the wet-chemical processor; design, fabricate, and test in breadboard form specific critical components of the unified system for Mars life detection; and establish feasibility of integration of a flight-type mass spectrometer with wet-chemical analysis.

W74-70672 **192-55-66**
Ames Research Center, Moffett Field, Calif.
PLANETARY ENVIRONMENTS
H. P. Klein 415-965-5094
(192-55-63)

Scientifically justifiable methods of analyzing biologically important environmental parameters are being studied for instrumental implementation. This is being done in order to assess the extent of a planet's biological habitability based on the planet's atmosphere and water history, and to select biologically enriched areas based on water availability and organic emissions.

W74-70673 **192-55-66**
National Aeronautics and Space Administration, Washington, D.C.
PLANETARY BIOLOGY
R. S. Young 202-755-3732

Analytical methods will be developed for the determination of biologically important planetary environmental characteristics such as composition of the atmosphere, presence or history of water, and occurrence of organic emissions. The methods and instruments so developed for planetary exploration will be useful in assessing a planet's ability to sustain a biota.

W74-70674 **192-55-68**
National Aeronautics and Space Administration, Washington, D.C.
SUPPORT ACTIVITIES
R. S. Young 202-755-3732

The AIBS Advisory Panels for OSSA are established to perform the following functions: (1) to evaluate the scientific merits of research proposals submitted by Program Chief(s) OSSA and advise Program Chief(s) on the scientific merits of said proposals; and (2) to plan, conduct and coordinate meetings of the panels, providing necessary secretarial service, including minutes of the meeting.

Planetary Quarantine

W74-70675 **193-58-61**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
STERILIZATION TECHNIQUES
John W. Lucas 213-354-4530

The objectives of this RTOP are to perform analytical and experimental studies in the area of planetary quarantine to evaluate potential contamination events of future missions. Specifically, these studies will include: (1) an evaluation of impact of planetary quarantine constraints on Jupiter-Saturn flyby missions, Saturn's rings encounter, and satellite encounters; (2) studies to determine the effect of the natural space environment on the survival of microorganisms. These studies are being conducted to identify planetary quarantine constraints for planned missions to better understand the requirements and to develop the procedures and methodology by which JPL or other NASA Centers can reliably satisfy these requirements. Existing JPL facilities will be used to conduct these studies and a multidisciplined team will be used to perform analysis for advanced missions. This team will include support for the definition of the natural space environmental parameters, spacecraft flight environments, mission analysis and microbiology.

W74-70676 **193-58-61**
National Aeronautics and Space Administration, Washington, D.C.
STERILIZATION TECHNIQUES
Lawrence B. Hall 202-755-3760

It is NASA's policy to avoid contaminating the planets with viable terrestrial life and to avoid negation of life detection experiments by contamination with terrestrial life. This can be accomplished by (1) avoiding contact with the planet, or (2) landing only space flight hardware that carries no life on board. The research will result in sterilization methods specifically tailored to the spacecraft. The technology that is being developed in the use of dry heat may have limited application to other fields, but alternative methods being developed to supplement dry heat may have widespread and economically important used in the sterilization of foods, pharmaceuticals, surgical supplies, and other fields in which biological contamination cannot be tolerated. The major approach to the sterilization of spacecraft has centered on dry heat. Other methods have been examined and found wanting on the basis of reliability, cost, safety, and other factors. In dry heat heavy emphasis has been and will continue to be placed on the definition of the amount needed to accomplish the purpose. Concurrently, a search is being made for acceptable alternative methods of sterilization that may be used for specific applications in which dry heat is not acceptable because of materials degradation. Included in this approach are studies of the lethal effect of the space environment encountered during the period of interplanetary cruise.

W74-70677 **193-58-62**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
MICROBIAL ANALYSIS
John W. Lucas 213-354-4530

The objectives of this RTOP are to develop analytical tools and perform experimental studies in order to estimate the recontamination hazard for spacecraft hardware. All physically significant parameters and processes are to be analytically modeled and experimentally verified, where possible, to obtain a reasonable level of confidence in the results. A combined discipline approach will be used to: (1) perform tests in existing JPL facilities in order to obtain data and verify the analytical recontamination models; (2) to perform sensitivity analyses to assess their impact of different mission strategies on recontamination.

W74-70678 **193-58-62**
National Aeronautics and Space Administration, Washington, D.C.
MICROBIAL ANALYSIS
Lawrence B. Hall 202-755-3760

The research program on microbial analysis stems primarily from the need to sterilize space flight hardware by the application of some form of stress to the organisms. As the organisms are stressed, they die, not all at the same time, but progressively in what is termed the 'logrithmic order of death.' Thus, the more organisms that are present, the more stress (usually dry heat) must be applied. Acting in the opposite direction, however, is the need to keep the stress to the essential minimum so that hardware reliability will not be degraded. For these reasons the number distribution, and types of microorganisms must be known in order that the optimum sterilization cycle may be applied. The applications of this technology are being and will be applied largely to spacecraft but the methods will also spill over into the hospital, food preparation, pharmaceutical, and surgical supply fields. The approach being taken includes the development of precise methods for the removal, numeration, and identification of all the bacteria from a representative surface; the recovery of a representative sample of the organisms that are buried in solids; the propagation of bacteria in aerosols; and the estimation by mathematical and computer techniques of the total bioload on and in a spacecraft. Concurrently, field applications are being carried out to provide experience with the technology and the base line data on missions that have been or will be landed.

W74-70679 **193-58-63**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
CONTAMINATION CONTROL
John W. Lucas 213-354-4530

The objective of this RTOP is to develop methodology and

procedures for the reduction of microbial burden on an assembled spacecraft at the time of encapsulation or terminal sterilization or during flight. This technology is required for: (1) determination of the sterilization process for a planetary lander or probe; (2) the reduction of excessive microbial burden on spacecraft components for the purposes of either decreasing planetary contamination probabilities for an orbiter or minimizing the duration of the sterilization process for a lander. The work will provide needed information concerning cleaning techniques that could significantly reduce microbial burden on spacecraft hardware. This RTOP contains a work unit which provides direct support to the NASA Headquarters Planetary Quarantine Office as requested.

W74-70680 **193-58-63**
National Aeronautics and Space Administration, Washington, D.C.
CONTAMINATION CONTROL
Lawrence B. Hall 202-755-3760

The probability of contaminating a planet by a flyby or orbiter spacecraft and the difficulty of achieving sterility of a landing spacecraft is related directly to the amount of biological contamination on the spacecraft. Therefore, the probability of contaminating the planet and the difficulty of sterilizing a landing vehicle can be reduced by contaminating the planet and the difficulty of sterilizing a landing vehicle can be reduced by controlling the amount of viable contamination that gets on and in the spacecraft during manufacture, assembly, test, and launch. The concepts and procedures resulting from this effort provide the measures used to keep a spacecraft biologically clean. The dissemination of these biological cleanliness procedures is of major importance to industry, particularly pharmaceutical and surgical supply industries. In the former the procedures developed for contamination control are saving millions of dollars a year by preventing the contamination of products. The technology is particularly useful in preventing contamination of tests, thus preventing false positives that result in the needless destruction of large batches of product. The approach to this problem centers largely in the evaluation, dissemination, and application of ultraclean techniques and in the gathering and recording of planetary quarantine publications.

Lunar Science SR&T

W74-70681 **195-42-50**
Ames Research Center, Moffett Field, Calif.
IMPACT CRATERING IN GEOLOGIC MATERIALS
Glen Goodwin 415-965-5065
(383-09-52)

The Vertical Gas Gun (VGG) and the Electrostatic Microparticle Accelerator (EMA) Ranges will be used to study cratering in unconsolidated materials of low cohesive strength and in massive rock. The effects of material strength and gravitational forces will be examined over a wide range of crater sizes. Previously developed techniques will be exploited to model and study other geologically significant formations for lunar and planetary applications. Results of studies will be combined with RTOP 383-09-52 Lunar Data Analysis for interpretation of the lunar surface morphology and evolutionary processes. The VGG will be used in studies of crater formation and of ejecta trajectories in gravitational fields of 1 to 0 g. Experiments on the EMA will focus on cratering efficiency (i.e. the ratio of eroded mass-to-projectile kinetic energy), effects of oblique impact, residual projectile material in craters, comminution of small particles, and calibration of micrometeorite detectors. Because the cratering process is controlled primarily by material strength and/or gravitational forces depending on crater size, target media will vary from unconsolidated material through bonded particulate material to massive rock in order to simulate to cratering of different scales and ascertain material strength effects. With the VGG, high speed photographic and stereoscopic techniques will be used to study crater formation and ejecta trajectories in gravity fields from 1 to 0 g. Modeling techniques that have been developed will be exploited to explore scaling laws for large craters and study geologically significant deformations and structures.

W74-70682 **195-42-51**
Ames Research Center, Moffett Field, Calif.
CHEMICAL AND ISOTOPIC STUDIES OF METEORITES AND ABLATION PRODUCTS
Glen Goodwin 415-965-5065
(385-45-01; 879-10-00; 188-45-53)

Chemical analyses via the electron microprobe permit determination of coexisting mineral compositions in meteorites, terrestrial analogs, and lunar samples. Knowledge of mineral compositions, together with textural studies, is needed to determine more precisely the physicochemical conditions of their origin, post-solidification thermal histories and shock events. Experiments will be devised to determine the feasibility of forming meteorites from a cold beginning. In addition, a study of the concentrations of the cosmogenic radionuclides in meteorites provides information regarding their preatmospheric entry size and their exposure age. Concentrations of such nuclides in meteorites are a function of chemical composition, meteorite size and exposure age. Thus comparisons can then be made among meteorite and terrestrial mineral assemblages for establishing more precise limits on meteorite parent body size, crystallization processes, and post-parent body breakup histories. Also, characterization of reactions and fractionated products will define the types of material being ablated from bodies during entry into the earth's atmosphere. This will enable new criteria to be developed for identifying debris ablated from sources such as meteoroids. Hence, it will be possible to identify extraterrestrial debris ablated from meteors and fireballs found in glacial ice sediments. Analyses to be conducted on specimens will include optical mineralogy, petrography, density, X-ray diffraction, X-ray fluorescence, electron microprobe, and scanning electron microscopy.

W74-70683 **195-42-53**
Ames Research Center, Moffett Field, Calif.
THEORETICAL STUDIES OF THE MOON AND METEORITE PARENT BODIES
Glen Goodwin 415-965-5065

The objectives are to obtain a better understanding of the structure, origin, and evolutionary history of the moon by means of theoretical investigations employing the results of lunar and ground based experiments. Theoretical and experimental knowledge of physical processes, and data, to construct and analyze mathematical descriptions of lunar and meteorite processes and structure. The results of these calculations are interpreted in terms of such topics as composition, material properties, and thermal history of the moon; solid state convection in the lunar interior; and the interpretation of rare gas studies of meteorites and lunar samples.

W74-70684 **195-42-54**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
LUNAR EXPLORATION OFFICE SUPPORT ASSIGNMENTS
J. D. Burke 213-354-6363

The objective is to continue the assignment of a JPL professional to the Lunar Exploration Office at NASA Headquarters to participate in various tasks being undertaken within the Lunar Science Program. The Lunar Exploration Office has defined several selected task appropriate for assignment to JPL personnel. Joint LEO-JPL review of potential candidates, including initial temporary assignments, has determined through mutual agreement the best match between candidate and task. The person presently on duty in Washington will continue into FY-74 to complete these assigned tasks.

W74-70685 **195-42-55**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
GEOLOGY AND MINERALOGY
Donald P. Burcham 213-345-3028

The geology and mineralogy program is a group of investigations directed at interpreting the results from Apollo missions, at interpreting previous lunar studies, at understanding the surface and subsurface properties of the moon, and performing appropriate

laboratory studies to increase our understanding of the moon. The fundamental emphasis is on deciphering the evolutionary history of this body and in determining its relation to the origin of the planets and the solar system. The specific tasks involved are: (1) detailed analysis of the lunar gravity field in terms of realistic geophysical models, and correlation of such models with observed lunar structures; (2) analysis of the lunar remnant magnetic field in terms of its global properties, together with interpretations (to the extent possible) of the origins of the field; (3) analysis of the thermal history of the moon including critical study of constraints supplied by analysis of returned lunar samples and geogphysical measurements on the moon itself; and (4) analysis of the thermoelastic strain history of the body, the response to tidal deformation, and correlations with observed seismic activity.

W74-70686 **195-42-57**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
PARTICLE TRACKING COSMOCHRONOLOGY
Donald P. Burcham 213-354-3028

This continuing work is undertaken to expand our understanding of the mineralogic settings and differentiation histories of lunar heat sources. Detailed microscopic distributions and the mineralogy and petrology of the heat producing elements U, Th, and K are required to understand their geochemical differentiation in the lunar environment. Such information will provide new constraints for lunar evolutionary models and will aid the interpretation of isotope chronology. The experimental effort involves the mapping of radioactive trace elements U, Th, and K by particle track and electron microprobe methods in order to determine their microscopic distribution and their mineralogy and petrology. Terrestrial and lunar materials will be chosen for their illumination of the lunar differentiation problem. An important objective for this task is to establish, in collaboration with colleagues at Caltech, a routine non-destructive method for thorium mapping. Specific information about the microscopic distribution is sought which will expand our understanding of the differentiation history of lunar heat sources.

W74-70687 **195-42-59**
Lyndon B. Johnson Space Center, Houston, Tex.
GEOSCIENCE RESEARCH RELATED TO LUNAR PROBLEMS
P. W. Gast 713-483-4464

Geochemical research covers development of the ion microprobe as a high resolution instrument for the determination of trace elements in geochemical research. The approach to farthering the development of the instrument will be initially through the determination of trace element composition of lunar feldspars. This development of quantitative ion probe analysis will be divided into three parts; analysis and evaluation of lunar sample data; electronic component development; and data reduction method development. Geophysical research involves second generation development of the Develco 4-inch rock magnetometer to achieve maximum sensitivity and to modify the instrument to permit the study of magnetic properties as a function of temperature. Geological research will advance the capability of the Scanning Electron Microscopy Laboratory by improving the data handling capability of the microscope and adding a capability to perform ion etching of the surface of rock samples to allow examination at higher magnification powers and to reveal great structural detail in three dimensions.

W74-70688 **195-42-63**
Goddard Space Flight Center, Greenbelt, Md.
ORIGIN AND STRUCTURE OF THE PLANETS AND THE MOON
C. C. Schnetzler 301-982-2282

The objective of the in-house research is to gain an understanding of the nature and origin of the condensed matter of the solar system. More specifically, activities will focus on time and mechanism of formation of the terrestrial planets, the moon and meteorites and subsequent modification of these bodies since formation. This includes, for example, development of the earth's core and formation and movement of the continents; development of the surficial topography of the moon by vulcanism and meteorite/cometary impact and comparison of magnetic differentiation processes of the moon and the earth. The approach will be multidisciplinary, involving the following areas: (1) analytical geochemistry - major, minor and trace element analysis; (2) geochronology - rubidum/strontium and potassium/argon age determinations; (3) radiochemistry - determination of cosmic-ray spallation products; (4) mineralogy/petrology - mineral compositions and textural relations; (5) crystallography - analysis of crystal structures; (6) geologic investigations - in situ (e.g., terrestrial craters) and photographs (e.g., lunar orbiters; earth satellites), and (7) theoretical study of lunar origin. The objective of the out-of-house research is to study the ablation of tektites. This theoretical study will correlate rough and smooth surface ablation and explain the differences.

W74-70689 **195-42-64**
National Aeronautics and Space Administration, Washington, D.C.
EARTH BASED OBSERVATIONS
R. P. Bryson 202-755-1948

Study of the lunar surface using earth-based instruments was continued. An image orthicon system attached to a 24-inch telescope is used to monitor the lunar surface for transient phenomena and to gain an understanding of the lunar surface and the processes that effect it. Studies of broad band reflection spectroscopy is used to determine the chemical and mineralogical composition of the lunar surface.

W74-70690 **195-42-65**
National Aeronautics and Space Administration, Washington, D.C.
THEORETICAL STUDIES
R. P. Bryson 202-755-1948

Scientific concepts are developed about the composition, structure, origin, and history of the moon and its constituent features requires an iterative process of data acquisition, synthesis, and theory. The evolving theoretical models of the moon have been constantly refined through testing and modification in this series of studies. Major areas of research include cosmogenesis, elemental, interaction of lunar materials with energetic particles, and thermodynamics of lunar processes.

W74-70691 **195-42-66**
National Aeronautics and Space Administration, Washington, D.C.
SCIENCE EXPERIMENT CONCEPTS
R. P. Bryson 202-755-1948

Experimental concepts are conceived, developed, and demonstrated that pertain to the lunar and/or planetary orbit and surface which require perfection of techniques of data reduction and analysis, and interpretation as well as investigation of concepts, instruments, and hardware including testing and calibration. These experiments emphasize geophysics and geochemistry.

W74-70692 **195-42-67**
National Aeronautics and Space Administration, Washington, D.C.
EXTRATERRESTRIAL MATERIALS
R. P. Bryson 202-755-1948

The objectives of extraterrestrial Materials program are to improve and extend scientific and technical knowledge of meteorites in order to increase our understanding of the composition and history of the solar system, give detailed information on present and past conditions of cosmic radiation in interplanetary space (space probes), and supplement studies of the chemical, physical, and geological properties of the lunar samples. The wide variety of experimental techniques available for meteorite study, including measurements in crystallography, mineralogy, radioactivity, particle tracks, chemical and isotopic composition, etc. - serve to give us detailed information on the origin, age, and history of these extraterrestrial objects.

W74-70693 **195-42-69**
National Aeronautics and Space Administration, Washington, D.C.

ANALOG STUDIES
R. P. Bryson 202-755-1948

Studies of terrestrial features that have been formed by similar processes to those that are believed to have shaped the moon's surface provide the data needed to interpret lunar history. Two types of features are being extensively studied, terrestrial meteorite impact structures, and terrestrial volcanoes and related features, since these appear to be the dominant lunar surface processes.

W74-70694 **195-42-70**
National Aeronautics and Space Administration, Washington, D.C.
LABORATORY SIMULATION
R. P. Bryson 202-755-1948

Study of the moon by experimentation in the laboratory includes study of the lunar surface by laboratory observations the effect of various types of solar radiation or silicate glass. Study through models, the lunar interior structure and evolution as constrained by the physical and chemical properties of minerals found on the moon. Study the shock effects, in the laboratory, of rock-forming minerals and the synthetic materials under a wide range of temperatures and pressures. Study shock metamorphism effects and cratering phenomena to impact parameters of meteroids using the laboratory facilities.

W74-70695 **195-42-71**
Langley Research Center, Langley Station, Va.
NEW TECHNIQUE FOR THE ACCURATE DEFINITION OF THE LUNAR GRAVITATIONAL FIELD
Eugene S. Love 703-827-2893
(383-09-54)

The objective is to develop new techniques for analyzing the data from lunar missions so as to better define the physical properties of the moon. Lunar gravity analyses have been hampered by the absence of direct measurements of the lunar farside gravity environment, and by the considerable roughness of the lunar gravity field. These factors require the estimation of a large number of coefficients which are highly correlated because of the limited data situation. The first portion of this work will involve the development of suitable constraints to stabilize and speed convergence of the solutions. These constraints will be based on such factors as lunar interior stress conditions; thus, this work will also involve a study of the relationship between the gravitational results and the interior composition of the moon. The second portion will involve the development of new techniques to obtain accurate values of the second degree and order coefficients of the gravity field. These coefficients are of particular interest since they define the moments of inertia of the moon. The analysis will be an attempt to develop a specialized filter for estimating a small number of parameters out of a large field.

Planetary Astronomy SR&T

W74-70696 **196-41-50**
Goddard Space Flight Center, Greenbelt, Md.
GROUND-BASED INFRARED ASTRONOMY
R. A. Hanel 301-982-4528

The scientific objective is to determine information on the atmospheres and surfaces of the planets from ground-based infrared measurements, obtained with high spectral resolution, of the planet's thermal emission spectrum. A double-beam Michelson interferometer has been used to obtain high quality spectra of Venus in the regions of the terrestrial atmospheric windows at 450-500 cm/1, and 1100-1200 cm/1 with a spectral resolution of 0.25 cm/1. Similar data but of lower quality and lower spectral resolution (0.5-1.0 cm/1) have been obtained for Mars. Attempts to measure the thermal emission spectrum of Jupiter have not been successful to date due to its very low infrared signal. Improvement of the present instrumentation and data acquisition electonics will allow further valuable planetary observations to be obtained. These observations include obtaining some spatial resolution for venus, measurement of the thermal emission spectrum in the 2000 cm/1 terrestrial atmospheric window for all of the planets, and obtaining higher quality spectra of Mars and Jupiter for all the terrestrial window regions.

W74-70697 **196-41-51**
Goddard Space Flight Center, Greenbelt, Md.
RADIO AND RADAR PLANETARY STUDIES
J. K. Alexander 301-982-5461

The objective of this program is to obtain information on the nature, extent, and dynamical behavior of planetary magnetic fields, trapped radiation belts, and magnetospheres by studying the nonthermal radio emissions from the planets. The three major approaches to this investigation are: (1) synoptic observations of Jupiter's decametric radiation via a five-station network of monitoring instruments; (2) observations of Jupiter and Saturn at meter and decameter wavelengths via very-long-baseline-interferometry; and (3) theoretical analyses of the generation and propagation of nonthermal radiation in a planetary magnetosphere. The Jupiter Monitor Network is providing unique data relative to the rate and stability of the magnetic field rotation, and the physics of satellite-plasma interactions in the magnetosphere; and correlative data for fly-by in-situ measurements. The VLBI measurements may provide the first positive detection of a Saturnian magnetic field.

W74-70698 **196-41-67**
Ames Research Center, Moffett Field, Calif.
PLANETARY ASTRONOMY AND SUPPORTING LABORATORY STUDIES
Glen Goodwin 415-965-5065

The abundance, temperature, and pressure of certain constituents of planetary atmospheres can be determined by spectroscopic observations from ground-based and from airborne observatories. Such data are necessary for the preparation of model atmospheres that are needed to evaluate the possibilities of life on the planets and to design systems for exploratory missions. The objective of this work is to make airborne and ground-based observations of planetary spectra, to obtain in the laboratory the spectroscopic parameters needed to analyze the observatory spectra, and to develop the analytical and computational techniques needed to interpret the spectra in terms of real planetary atmospheres. The spectroscopic parameters such as absorption intensity and line widths, and their temperature and pressure dependences will be obtained using long path gas cells, cooled gas cells and high resolution spectrometers and interferometers operating primarily in the infrared.

W74-70699 **196-41-71**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
GROUND-BASED OPTICAL ASTRONOMY
Donald P. Burcham 213-354-3028
(196-41-74)

The objective is the comprehensive study of solar system bodies through ground-based astronomical observations. Specific emphasis is placed on high-resolution spectroscopic observation of the outer planets Jupiter, Saturn and Uranus. The principal instrument used in this effort is the high-resolution spectrograph and its ancillary equipment at the coude focus of the Table Mountain Observatory 24-inch telescope. Specific objectives for FY-74 include reduction and analysis of data on the abundance and temporal variation of H2 on Saturn, observation of the spatial and temporal variations of H2, CH4 and NH3 on Jupiter. In support of these main programs are sub-programs which include compilation of a library of comparison solar/telluric spectra, and construction of a high photometric accuracy, high-resolution image tube scanner for the coude spectrograph. To conclude the Venus prpgram one more multi-observatory joint patrol is planned tentatively for Fall, 1973. Every attempt will be made to insure the best temporal coverage possible in order to precisely determine the characteristics of the cloud variability. Also planned are additional observations of the weak 7105, 7158 and 7200 A CO2 bands in the spectrum of Venus in order to determine spectroscopic band constants.

W74-70700 **196-41-72**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena

GROUND-BASED INFRARED ASTRONOMY
Donald P. Burcham 213-354-3028

The objective of this task is to obtain and analyze high resolution infrared spectra of the planets in the 1 to 6 micron region in direct support of on-going and planned planetary missions. The primary approach employed is the analysis of spectra produced with a Connes-type Fourier spectrometer at the 107 in. telescope, McDonald Observatory, University of Texas. Ancillary approaches involve the use of laboratory infrared spectroscopy *and data compilations for the analysis of spectra, together with* significant operational efforts, in the fields of radiative transfer and model atmospheres. Interpretation of the data also feeds back to the development of new instrumentation to support both the present work and potential spacecraft missions. For instance, a spatialspectral multichannel scanner which operates on the 5 micron CH3D band would be of great value in investigating the *cloud morphology of Jupiter both from the ground at low spatial* resolution and from a flyby/orbiter at much higher spatial resolution. We propose to construct such a device.

W74-70701 **196-41-73**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
RADIO AND RADAR PLANETARY STUDIES
Donald P. Burcham 213-354-3028

The objective task is to conduct a comprehensive program in ground-based planetary radio astronomy. Jupiter, Venus, and Saturn are prime planets of interest in this program. Radio astronomical observations provide data on the properties of planetary atmospheres, magnetospheres, and surfaces. A microwave radiometer development program is conducted to *provide support for the observational radio astronomy program.* The support objectives are to design, construct, test, and maintain advanced microwave radiometer systems for use at Table Mountain, Goldstone, and Owens Valley radio observatories. Equipment used in the course of this task includes the facilities and test equipment of the Table Mountain Obervatory and the Deep Space Network. The facilities include the 5-m millimeter *wave antenna at Table Mountain, and the 26-m, and 64-m* antennas at the Goldstone Tracking Station. Observations at other observatories are carried out as required by the specific needs of the program. Another objective is to obtain radar data on the planets for determining properties of their surfaces and atmospheres, with Venus, Mercury, Mars, and Saturn's rings as prime goals. This work employs the unique facilities of the *DSIF, and exploitation of synthetic aperture techniques.*

W74-70702 **196-41-80**
National Aeronautics and Space Administration, Washington, D.C.
GROUND-BASED OPTICAL PLANETARY ASTRONOMY
W. E. Brunk 202-755-3660

The objective is to increase knowledge of the planets, their satellites, and other solar system bodies through the use of astronomical observations made with telescopes and other optical instruments located at ground-based observatories. The observations will be made throughout the visible and infrared portions of the spectrum. Reduction, interpretation, analysis, and publication of the data thus obtained are included as part of the objective. The approach will be to utilize the interest, experience and facilities of scientists outside of NASA to obtain data needed to support and supplement the planetary flight program. The program included under this RTOP covers observational and the associated theoretical studies of the planets, their satellites, and other solar system bodies in the optical and infrared portions of the spectrum made from ground-based observatories. The results of these studies are published in the open literature. The planetary science expertise and observational facilities required for this program are, in general, not available within the NASA centers. During fiscal year 1973, over 40 individual observational programs were carried out under 22 tasks involving 15 separate universities and other institutions. The program is designed to increase understanding of the planets---

W74-70703 **196-41-81**
National Aeronautics and Space Administration, Washington, D.C.
ASTRONOMICAL OPTICAL INSTRUMENT DEVELOPMENT
W. E. Brunk 202-755-3660

The objectives are to design, develop, and construct optical telescopes and auxiliary instrumentation to be used for ground-based astronomical observations. The auxiliary instrumentation includes such items as cameras, photometers, spectrometers, interferometers, etc. The scientific return that can be obtained under RTOP 196-41-80 is limited by the facilities and instrumentation available to the investigators. The actual level of scientific *return possible from ground-based observations in the optical* and infrared, could be much higher if additional facilities and auxiliary instrumentation were available. Such facilities or instrumentation is developed under this task when the magnitude of the development is too great to be considered as part of the research task. Recently, tasks generally included under this RTOP are for either of the following: (1) design, development, *construction and testing of auxiliary instrumentation involving* new observational concepts such as the recent, non-NASA supported development of the 2-dimensional silicon vidicon photometer; and (2) construction of proven types of auxiliary instrumentation such as---

W74-70704 **196-41-82**
National Aeronautics and Space Administration, Washington, D.C.
GROUND-BASED RADIO AND RADAR PLANETARY ASTRONOMY
W. E. Brunk 202-755-3660

The objective is to determine planetary properties by *observations from ground-based observatories at radio wave*lengths. Both passive (radio) and active (radar) observations will be performed. The program will include the reduction, analysis, and interpretation of the observations. The approach will be to utilize the interest, experience and facilities of scientists outside of NASA to obtain data needed to support and supplement the planetary flight program. The program included under this RTOP *covers observational and the associated theoretical studies of* the planets, their satellites and other members of the solar system in the radio portion of the spectrum made from ground-based observatories. Both passive, radio astronomy, and active, radar astronomy, observing techniques are included under this RTOP. The results of these research programs are published in the open literature. The planetary science expertise and observational *facilities used in this program complement those available within* the NASA centers and the Jet Propulsion Laboratory. During fiscal year 1973, a large number of observational programs were carried out under 8 tasks (6 radio, and 2 radar) involving 7 institutions. The program is designed to increase our---

W74-70705 **196-41-83**
National Aeronautics and Space Administration, Washington, D.C.
RADIO AND RADAR ASTRONOMY INSTRUMENT DEVELOPMENT
W. E. Brunk 202-755-3660

The objectives are to design, develop, and construct instruments to be used for radio and radar astronomy at universities and other non-NASA organizations, with emphasis on observations of the planets. The program includes the development of auxiliary instrumentation such as radiometers for existing radio and radar facilities as well as the construction or modification of major facilities when required. The scientific return that can be obtained under RTOP 196-41-82 is limited by the capabilities of the facilities and instruments available to the investigators. The actual level of scientific return possible from ground-based observatories could be much higher if new instrumentation or facilities were available. Such instrumentation is developed under this RTOP. At the present time the only task under this RTOP is for the development of a high-power S-band radar system for the Arecibo Observatory in Puerto Rico. Upon completion, Arecibo will be the most powerful radar astronomy telescope in the United States. Basic funding for the radar system was completed in fiscal year 1973 but the construction of the system will not be completed until mid-fiscal year 1975.

W74-70706 **196-41-84**
National Aeronautics and Space Administration, Washington, D.C.
LABORATORY SUPPORTING STUDIES (ASTRONOMY)
W. E. Brunk 202-755-3660

The objective is to obtain laboratory data required for the analysis and interpretation of planetary observations made from the vicinity of the earth. The data obtained will be of two types: first, detailed study of gases and other materials known to exist on a planet and, second, study of the properties of many possible materials to try to explain unidentified features detected in planetary observations. The data obtained under this program will be published as well as being used directly in the interpretation of new observations. Principal Investigators on tasks under RTOP 196-41-80 frequently find that there is insufficient laboratory data on the spectra of the molecular constituents they are observing. Needed are data for specific molecules at conditions and wavelengths not normally encountered in laboratory studies. It is therefore necessary to obtain the needed data using specialized very long path absorption cells at a range of temperatures and pressures. Tasks under this RTOP support such programs at non-NASA institutions. The technical plan is to determine laboratory values of the properties of materials known or suspected to be observed on the planets. Existing laboratory facilities will be used as much as possible---

W74-70707 **196-41-85**
National Aeronautics and Space Administration, Washington, D.C.
THEORETICAL PLANETARY ASTRONOMY
W. E. Brunk 202-755-3660

The objectives are to provide theoretical support for the planetary astronomy program by predicting what data should be observed and by explaining the observational results, both predicted and unexpected. The program also involves the integration of observational and laboratory results from many sources to provide an explanation of planetary phenomena. Thus, this program provides an important link between the observational and laboratory programs and an understanding of the planets. Based on prior knowledge of the planets and existing physical laws, programs are undertaken to predict the observational data on the planets. As an example, theoretical atmospheric spectra are generated using assumed knowledge of the planetary atmospheric constitutents, the spectral effects produced by a scattering atmosphere containing aerosols, and the dispersion of the theoretical calculations. On the other hand, theoretical programs are also undertaken in an attempt to understand unpredicted observational results such as---

W74-70708 **196-41-86**
National Aeronautics and Space Administration, Washington, D.C.
AIRCRAFT-BASED PLANETARY ASTRONOMY
W. E. Brunk 202-755-3660

The objectives are to observe the planets and their satellites using telescopes and associated equipment mounted aboard high altitude aircraft. Observations will be made primarily in the infrared from altitudes above the tropopause where the integrated water vapor content of the remaining atmosphere is below approximately 10 microns. Under these conditions it is possible to observe throughout almost the entire infrared portion of the spectrum. This program has two major aspects. The first provides for the operation of high altitude aircraft properly instrumented for astronomical observations. This aspect of the program is presently handled under a separate RTOP through the Ames Research Center. The second aspect is the development and carrying out of specific research programs by investigators both inside and outside NASA. This RTOP covers the support of non-NASA investigators in planning and executing the high altitude observational program as well as the reduction, analysis, and interpretation of the observational data. Emphasis during the coming year will be on spectral observations of Mars and far infrared photometry of the other planets. The program carried out under this RTOP is closely coordinated with the NASA center related aircraft flight programs.

OFFICE OF TRACKING AND DATA ACQUISITION

Tracking, Orbit, Determination & Ground Based Navigation

W74-70709 **310-10-22**
Goddard Space Flight Center, Greenbelt, Md.
MISSION SUPPORT COMPUTING SYSTEMS AND TECHNIQUES
D. S. Woolston 301-982-5571
(310-10-26)

The major objectives of the efforts discussed are to provide flexible and economical mission support computing systems to meet the operational needs of forthcoming spacecraft missions in the areas of orbit and attitude determination. In the development of orbit determination systems and orbit generators, this has been an on-going effort under this RTOP, and many advances in numerical and analytical techniques have been made. These will be evaluated and exploited, and new techniques will be explored. Much of the effort will be directed toward finding the most effective and most efficient combination of techniques for a given application. New statistical filtering techniques will be examined which decouple orbit and model parameter estimation to efficiently produce an accurate orbit in the presence of unmodeled accelerations. This also has application to attitude determination. A further objective will be to explore the possibility of reducing ground based tracking and orbit determination requirements by examining new and unique ways of determining a spacecraft's attitude and orbit. The information content of attitude telemetry data, for example, should be useful in orbit determination and could, for some applications, eliminate the need for tracking. Also, in the area of attitude determination, consideration will be given to the development of a main frame support system to be readily adaptable for the incorporation of future mission requirements.

W74-70710 **310-10-26**
Goddard Space Flight Center, Greenbelt, Md.
TRACKING DATA AND TRAJECTORY ANALYSIS
J. L. Cooley 301-982-5671
(310-10-22)

The objectives of this RTOP are to increase the efficiency and decrease the resources needed to meet the requirements of spaceflight missions and tracking experiments scheduled for the mid-1970's era (such as earth resources, synchronous, and lunar mission classes). This will be done by (1) improving the quality and usage of tracking data for orbit determination, guidance, maneuver, control, and orbit adjust; (2) providing computational techniques and simulation packages to study how the navigation and maneuver requirements of future missions may be most efficiently met; and (3) providing computational techniques for trajectory, navigation, guidance, maneuver, control and orbit adjust functions to optimize future operational support. The approach involves examining aspects of tracking data handling procedures (such as preprocessing, data smoothing, data editing, data modeling, data error sources, and data calibration) in order to define technically feasible procedures which will provide reductions in cost, reductions in the use of facilities, and reductions in data needs to support future mission requirements. An examination will be made of the limitations of present technology to simulate, study, and support orbit determination, guidance, maneuver, orbit adjust, control, and trajectory requirements in support of future spaceflight missions. Simulation software will be developed for mission classes to study new techniques and examine new procedures for meeting mission requirements.

W74-70711 **310-10-42**
Goddard Space Flight Center, Greenbelt, Md.
FREQUENCY STANDARD SOURCES
H. E. Peters 301-982-4682

This RTOP is for the development of improved frequency

and time standards to meet NASA's requirements in several important applications. For optical and microwave tracking, .2 microseconds timing and 10 to the minus 14th power long term stability is required; for VLBI, 5 x 10 to the minus 15th power stability for 10,000 seconds measuring time is needed; and for precise time and frequency dissemination, .2 microsecond timing and 10 to the minus 14th power long term stability is required. For basic calibration and standards use, 10 to the minus 14th power accuracy and 10 to the minus 15th power reproducibility is needed. In Task A, construction of two new hydrogen masers, which were begun in 1973, will be completed in 1974, and performance tests will be started. An outgrowth of previous GSFC maser research, these units will be illustrative of advanced design capabilities. In Task B, development of the hydrogen beam resonance standard will be continued. For both NASA and other scientific applications, this standard promises to be the most fundamental and accurate device achievable, with accuracies in the 10 to the minus 14th power or better range. In FY-73 we have achieved success with resonance measurements of 580 Hz halfwidth at detected beam intensity of 10 to the 8th power atoms per second and kinetic temperature of 15 Kelvin. In FY-74 we will attempt to establish the lower temperature limit of the velocity distribution and to try better atom detector devices. We will also begin the design of an advanced basic standard on the basis of these and other results to date.

W74-70712 **310-10-60**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
NAVIGATION ACCURACY ANALYSIS
D. W. Trask 213-354-4878
(310-10-61; 310-10-62; 310-10-64; 310-10-66)

Those DSN tracking system uncertainties which limit spacecraft navigation capability now and in the future will be determined. Methods of removing these limitations and more effective uses of existing tracking stations such as the multistation tracking techniques needed by missions to the outer planets will be developed and analyzed. These multistation tracking techniques which generally use two DSS separated by a very long baseline (VLB) in an interferometric (I) mode include the differencing of simultaneously acquired conventional DSN ranging (ranging QVLBI) or Doppler (Doppler QVLBI) data, the simultaneous open loop recording and later cross correlation of the signal from a natural source (VLBI) or a spacecraft (S/C VLBI) and differential VLBI (delta VLBI) which is the difference between the cross correlation results of two simultaneous VLBI-type measurements. In practice, delta VLBI is used to measure the S/C position with respect to an angularly nearby extragalactic radio source (ERS). Demonstrations to prove the advantages of multistation tracking techniques with PN10/11 and MVN 73 in configurations which simulate VK75/MJ377 navigation, will be planned and executed in anticipation of outer planet missions and solar electric applications. The relative contributions of DSN tracking system error sources to orbit estimation will be examined in the presence of single and multistation radiometric data types, both to develop and refine models of tracking system errors and to determine where improved equipment/calibration techniques are needed. Currently the main thrust includes developing better practical techniques to calibrate the effects of the transmission media (troposphere, ionosphere, and space plasma) on radio metric data and to reduce the platform--

W74-70713 **310-10-61**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
INSTRUMENTATION FOR NEW TRACKING DATA TYPES
Dan A. Bathker 213-354-3436
(310-10-61; 310-10-62; 310-10-64; 310-20-65; 310-20-66)

This RTOP develops and demonstrates instrumentation and techniques to generate tracking data types required for the next decade deep space missions. These data types include simultaneous S- and X-band down links, S/X dual channel ranging and two-station tracking. Simultaneous S/X-band down links will lead to calibration of intervening charged particles, dual channel ranging leads to absolute electron content, while two-station tracking yields microradian angle and angle rate data. MVM'73, MJS'77 and future long lived spinning spacecraft require improved navigation for targeting goals and reduced on-board fuel requirements. Additionally, X-band will be required for future planetary missions because of the crowded S-band spectrum and because of the additional gain available at X-band on links using area limited antennas. The Venus-Mercury mission will provide an opportunity to determine the operational problems to be encountered in an X-band interplanetary link. Simulations of a telemetry link will be made to demonstrate future communication capability in this frequency band, under RTOPS 66 and 67, using the X-band ranging channel provided under this RTOP. Reflex dichroic S/X-band feed and improved dual channel S/X-band sequential component ranging will both be demonstrated using MVM'73. The reflex feed will feature simultaneous S- and X-band efficiencies and operating noise levels essentially equal to older, single band optimized feeds. The digital ranging demodulation will feature direct digitizing of the 10 MHz IF. Sub-microsecond time synchronization using quasars as noise sources will expand upon VLBI work, but use improved processing techniques and avoid use of station recording equipment. Such 10 nanosec sync is needed for two-station simultaneous ranging, a requirement for missions such as MJS'77 as well as some inner planet and most solar electric missions. It will be demonstrated between Goldstone and the Madrid complex.

W74-70714 **310-10-62**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
S-BAND RANGE AND DOPPLER QUALITY
Richard L. Sydnor 213-354-2763
(310-10-60; 310-10-61; 310-10-64; 310-20-66)

Tracking requirements of the DSN tracking stations over the next decade involve measurements at greater distances for such missions as MJS'77 and other outer planet flybys, the necessity for providing improved S-band range and Doppler quality in order to meet the requirements of radio navigation and radio science in these extreme range missions, and the necessity of two station tracking to improve the navigation capability for these low declination and nonballistic missions. Accurate differenced range versus integrated Doppler (DRVID) measurements for calibration of the propagation path will be required for the more demanding navigational and science needs for calibration of single station Doppler and for two station differenced Doppler (QVLBI). To achieve this performance, the work under this RTOP is concerned with stable generation, control and distribution of frequencies, and stable phase and group delay in the DSN tracking system, leading to more accurate and stable two-way and three-way tracking with spacecraft. To these ends this RTOP will (1) develop reliable hydrogen masers for ultra stable frequency generation for improving Doppler and range data over the long round trip light times, maintaining time synchronization between sites, for improved radio navigation by the use of two station tracking a low declimation angles (to be demonstrated with Viking Orbiter), for use in differential VLBI and for use with VLBI to determine tracking station locations accurately; (2) develop techniques for improving the signal delay stability through RF modules and cables to improve ranging calibration precision and stability; and (3) develop techniques for distributing hydrogen maser signals throughout a DSN complex without degradation, in order to enable the entire complex to achieve this level of performance without the expense of multiple installation of hydrogen masers. The transmitter advanced engineering is transferred to RTOP 68 for continuation of the automation effort.

W74-70715 **310-10-64**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
X-BAND RADAR DEVELOPMENT
R. L. Leu 213-354-5692
(310-10-60; 310-10-61; 310-10-62; 310-20-64; 310-30-68)

This RTOP develops an X-band radar capability to obtain operational experience at this frequency, to prepare for an X-band uplink for flight project support, and to obtain planetary data to assist in future flight project mission design. A gain of up to 7 db over S-band radar will be achieved on targets without dense atmospheres. Thus, better experiments can be done on the rings of Saturn, Mercury, Mars, and Jovian Moons, and asteroids. The wider bandwidth available at X-band allows finer range gates which can be used to improve mapping and altitude

resolution and obtain better ephemerides as well. The rings of Saturn must be studied as a possible hazard to navigation in the MJS'77 flight project. The design and procurement of the X-band radar was started in FY-72 and continued in FY-73. The design and procurement will be completed in FY-74. High power testing will be started in FY-74 and completed in FY-75. Installation and testing at DSS-14 will be---

Spacecraft-to-Ground Communications, Telemetry & Command

W74-70716 **310-20-20**
Goddard Space Flight Center, Greenbelt, Md.
TRACKING AND DATA RELAY SATELLITE TECHNOLOGY DEVELOPMENT
George Q. Clark 301-982-6331

The two objectives are: (1) to provide for the simulation and preliminary design of a Tracking and Data Relay Satellite System to be used for support of NASA missions, and (2) to provide for the orderly development of the technology required for implementing a first-generation TDRSS by 1977. Various studies, simulations, and model fabrications will be performed to establish the parameters for a TDRSS, while other studies will identify and provide solutions to problems inherent in the system. In addition, technology will be developed as required for a first-generation TDRSS.

W74-70717 **310-20-23**
Goddard Space Flight Center, Greenbelt, Md.
INVESTIGATION OF EQUATORIAL IONOSPHERIC PROPAGATION
T. S. Golden 301-982-4297

Information on factors which tend to degrade signal quality must be known with confidence to design a space-to-earth link for telemetry or tracking. Adequate operating margin must be built into the system to preserve the desired data quality. The amount of margin is determined through available knowledge of the degrading factors. Considerable knowledge of equatorial ionospheric fading for VHF in South America is now available through previous SRT investigations. Recently surprising amounts of fading at microwave frequencies from ATS-5 (1.55 GHz) and ALSEP (2.3 GHz) have been observed near the equator. In addition there is preliminary evidence of a longitudinal dependence in the ALSEP data. These discoveries may impact microwave link design and station location criteria for future missions. Adequate knowledge of geographic dependence is not presently available. Present statistical data for microwaves is based on less than 200 hours of observation. The objective in this work is (1) to expand the present scintillation data base as to geographic and frequency dependence; (2) to compare scintillation characteristics with telemetry bit error rate; and (3) to qualify the technique and approach used as a means of making future amplitude scintillation measurements. The NASA archives of magnetic tape records include considerable data on received signal power (AGC).

W74-70718 **310-20-27**
Goddard Space Flight Center, Greenbelt, Md.
NETWORK TIMING AND SYNCHRONIZATION TECHNOLOGY
A. R. Chi 301-982-2502

The objectives are to: (1) study and develop techniques for time synchronization; (2) coordinate time determination methods and dissemination formats to meet NASA needs and network requirements; (3) apply known technology to planned or existing systems which may or may not be solely NASA supported programs; (4) initiate and review development programs which meet present and future needs of the network including hardware and software development where appropriate; and (5) conduct theoretical investigations and experimental tests for network applications. A single worldwide time synchronization reference system using the Navy's Omega navigation system as a carrier has been investigated. Receiver hardware for time extraction from the carrier signals has been developed. Field test of the receiver and system capability is ready and planned for FY-74. Construction of Omega transmission format as presently constituted includes two side frequencies which are separated by 250 hertz for time transmission. The system precision is 90 microseconds at cycle identification level and 1 to 5 microseconds after a carrier cycle has been identified.

W74-70719 **310-20-31**
Goddard Space Flight Center, Greenbelt, Md.
A GROUND ANTENNA FOR WIDEBAND DATA TRANSMISSION SYSTEMS
L. R. Dod 301-982-5319

Future advanced spacecraft systems will transmit data to the ground at rates much higher than that of current operational systems. The Earth Observation Satellite (EOS) will transmit high resolution color TV either directly to a ground station or via a Tracking and Data Relay Satellite (TDRS). The TDRS will transmit signals from EOS and other satellites which required total TDRS bandwidths approaching 1 GHz. Existing NASA ground stations are not equipped for such data rates. Future wideband communication by TDRS, EOS and other projects, require use of frequencies at which the necessary bandwidth can be allocated. A wideband (approximately 1 GHz) system requires a high performance ground antenna system. Emphasis on overall system efficiency will be essential to an economically feasible ground station. In particular, techniques and components will be developed which yield high efficiency antenna systems, feed systems, and low noise preamplifiers. In addition, dichroic subreflector techniques permitting simultaneous and efficient operation of an antenna at different frequencies without degradation of overall performance or flexibility will be refined. Analytical procedures and design tools will be further developed to support the specific requirements of these advanced antenna systems and the general antenna development program.

W74-70720 **310-20-32**
Goddard Space Flight Center, Greenbelt, Md.
HIGH RELIABILITY CONTROL SYSTEMS FOR ANTENNAS
N. A. Raumann 301-982-6579

Concentration of data acquisition responsibilities and increasing data bandwidths resulting from reduction in the number of network stations are placing greater loads on the network links. Thus, the cost of link down time is increased, requiring a corresponding increase in link reliability. The antenna control system is one of the few components to which redundancy cannot be economically applied. In addition, link down time due to alignment requirements and routine maintenance has to be minimized. At the same time a reduction in maintenance and operation (M and O) manpower is highly desirable. Above objectives are met by the tasks in this RTOP. The computer controlled antenna system has demonstrated a potential for marked reduction in (M and O) manpower and the functions of several equipments have been successfully integrated. This system is operating experimentally at the Network Test and Training Facility (NTTF) and it will support the STADAC system. The acoustical analysis equipment for detecting and identifying incipient failures in hydraulic and mechanical systems has been installed on ten network antennas. In addition to direct support to the network, these installations will provide field data for further evaluation and analysis technique development under this RTOP. Study efforts in progress will define the design characteristics for a high accuracy control system which is required for future antennas operating in the Ku-band such as the ground station in support of the Tracking and Data Relay Satellite (TDRS).

W74-70721 **310-20-46**
Goddard Space Flight Center, Greenbelt, Md.
UNIFIED SPACECRAFT RF SUBSYSTEM DEVELOPMENT
A. F. Block 301-982-4158

This RTOP provides the design and supporting fabrication documentation required to procure S-band transponders for a wide variety of tracking, telemetry, and command requirements. It (1) identifies the basic operational requirements of earth orbiting spacecraft; (2) develops a design incorporating the best available components and fabrication techniques as proven in a prototype transponder; and (3) provides manufacturing drawings and other

documentation to spacecraft programs to permit fabrication of flight hardware with little or no modification to fit unique requirements. It also develops high power/high frequency transistors for future spacecraft transmitting requirements. Previous work on this task has enabled transistor RF outputs of up to 20 watts at S-band. Work started in FY-73 was directed to higher frequencies. To achieve acceptable solid state amplification outputs at 4 to 5 GHz, X-band and beyond a first goal was identified as five watts in the 4 to 5 GHz region. Due to a change in the financial picture, this contract was terminated in March, 1973. It is planned to restart this program in FY-75.

W74-70722 **310-20-65**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
ANTENNA SYSTEMS DEVELOPMENT
H. P. Phillips 213-354-4743
(310-20-61; 310-26-64; 310-20-66; 310-20-68)

This RTOP develops the increased performance and reduced costs of the DSN ground based antennas necessary to meet the expanding communications requirements of approved NASA planetary missions and makes available technical advances and capability options to support the planning of projected missions in these series. The objective of the RTOP is to achieve the maximum overall economy in spacecraft communications, while meeting expanding mission requirements. Advances are sought in the field of RF optics, antenna structural and mechanical design, pointing systems, measurement and calibration techniques, station automation, and in design and construction techniques with the potential of making larger, higher gain antennas possible and cost effective. Current efforts include S-X band dual frequency feeds to provide for increased radiometric tracking accuracy and to improve the data rate capability of the communications link, studies of extension and shaping of the 64-m reflectors as a low cost gain improvement method; the potential of a 128-m antenna for outer planet missions; and RF techniques to reduce noise and improve the antenna figure of merit. Engineers assigned to the development tasks are those directly responsible for the design of the operational equipment, maintaining a continuity of responsibility from development through prototype installation, calibration and operational usage. Development efforts are carried on at JPL, and occassionally in other laboratories having unusual capabilities in specific fields of interest. Contact is maintained with other laboratories and institutions doing work of interest applicable to the DSN antenna systems.

W74-70723 **310-20-66**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
RADIO SYSTEMS DEVELOPMENT
Walter H. Higa 213-354-4240
(310-10-61; 310-10-62; 310-10-64; 310-20-65; 310-20-67)

The objective of this effort is to improve the spacecraft-to-ground radio communications link in order to meet the future high data rate requirements of the planetary exploration program. Future missions to the outer planets, such as MJS'77, will require wideband radio communications for high rate video, telemetry, navigation, and radio science data. Hardware development includes wide bandwidth, high gain, and very stable X- and K-band traveling wave masers using superconducting magnets. It has been demonstrated that superconducting magnets provide the kind of phase stability which is required for precision ranging. An X-band telemetry experiment is planned with the MVM'73 mission. The S-band ranging signal from the DSN to the spacecraft will be turned around and retransmitted to the ground station at X-band. This demonstration is necessary for the DSN to be prepared to meet the X-band commitment for MJS'77. In order to prepare for future data dump telemetry at X-band, a detailed investigation of the propagation medium is planned. Specifically local weather effects on X-band are being investigated and will ultimately provide DSN specifications for the statistical performance commitment of X-band links to flight projects. Studies of the interplanetary medium and its effects on X-band will also be made. Planetary entry propagation characteristics for each of the planets as well as solar occultation effects will be investigated for support of future missions. This RTOP provides support of spacecraft occultation experiments by providing co-experimenters.

W74-70724 **310-20-67**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
DIGITAL SYSTEMS DEVELOPMENT
R. A. Winkelstein 213-354-3843
(310-20-65; 310-20-66; 310-30-68; 310-30-69)

The objective of this RTOP is to develop digital data handling systems which permit effective communications between earth and spacecraft for mission types of the next decade while minimizing the cost of such communications. As specified in the new OTDA charter, the entire communication link from the Mission Control and Computing Center (MCCC) to the spacecraft and back again will be considered in order to provide spacecraft/ground system tradeoffs which will result in lowest overall costs to NASA. In particular, a variable rate flight/ground command system will be developed and demonstrated which will permit more rapid entry of commands during periods when the uplink can support greater rates, thus shortening the high cost, high activity command transmission time at the DSN stations. An X-band telemetry experiment using the MVM'73 ranging channel will be carried out to demonstrate the higher data rates obtainable by taking advantage of increased antenna gain at frequencies higher than current S-band operation. The effects of weather on X-band transmission will be evaluated by correlating the received signal-to-noise ratio to various conditions of cloud cover, monitored under RTOP 66. Also included in this experiment will be the use of Viterbi decoding hardware and Golay decoding software to demonstrate the effectiveness of concatenated coding of data with short constraint length convolutional codes to reduce error probabilities on the science channel. Multiple frequency shift keying (MFSK) receiving equipment will be constructed and demonstrated at rates up to 20 symbols per second. Since MFSK telemetry does not require a coherent carrier frequency, communications using MFSK can be possible over phase-incoherent transmission paths such as lie close to the solar corona or from probe type missions to planets with turbulent atmospheres. MFSK can also provide usable capability from missions whose distance is greater than 30 AU from earth.

Network Operations and Control Technology

W74-70725 **310-30-21**
Goddard Space Flight Center, Greenbelt, Md.
ADVANCED NETWORK PLANNING
C. H. Underwood 301-982-2357

This task addresses the total scope of problems which are related to the technical integration of the STADAN and the MSFN into the STDN and the development of plans, programs, and techniques required to update the network. This task will emphasize those areas which maximize the effectiveness of the support provided and increase the cost effectiveness of the total network. Advanced and state of the art techniques will be identified and their potential impact upon the network will be evaluated along with their mission support capabilities. Specific objectives of this task which will affect all elements of the network, including remote sites and data handling systems, are identified in the following broad areas: (1) integration of MSFN and STADAN networks, (2) TDRS impact on the network, (3) advanced network system support/cost trade-off data, (4) advanced telecommunications systems, and (5) tracking coverage modeling.

W74-70726 **310-30-24**
Goddard Space Flight Center, Greenbelt, Md.
30 MBPS STATION DATA HANDLING EQUIPMENT
Henry J. Franks 301-982-2649

The 30 megabit per second station data handling equipment research program will investigate concepts for demodulating, synchronizing, decommutating and recording spacecraft telemetry data at rates up to 30 Mbps. A demodulator will be designed to interface with the existing multifunction reserver (MFR) that will permit bi-phase and quadraphase demodulation at data rates up to 30 Mbps. A bit synchronizer/signal conditioner will be designed to interface with the above demodulator to generate

noiseless data and clock signals at rates up to 30 Mbps. A study will be initiated that will investigate the error encoding and demultiplexing required by a 30 Mbps magnetic tape recorder with the aim of providing the decommutation necessary for stripping the data required in real time.

W74-70727 **310-30-35**
Goddard Space Flight Center, Greenbelt, Md.
NETWORK UTILIZATION AND SHUTTLE STUDIES 1979-1990
C. M. Uvaas 301-982-2357

The objectives are to perform advanced system planning to formulate and develop comparative models of network support capabilities and network resources that will be required to provide ground support of shuttle and shuttle launched payloads in the 1979-1990 time frame. The network resources would include a Tracking and Data Relay Satellite (TDRS) system plus 8 to 11 ground stations for supporting shuttle orbiter, sortie labs, space tugs, and payloads injected into synchronous orbit and beyond or orbits above 350 n.mi. with the space tug, as well as payloads launched via conventional Delta boosters during the interim phase-over period to shuttle launches. The planning model will indetify system capabilities, operational philosophy, and new technology associated with the new generation of spacecraft and shuttle launched vehicles in sufficient detail to define hardware system requirements for the ground support network. The approach will be to investigate support requirements of future manned and unmanned missions such as shuttle, Large Space Telescope, space stations/platforms, TDRS, Earth Observatory Satellite, High Energy Astronomy Observatory, Orbiting Solar Observatory, Earth Resources Technology Satellite, Synchronous Earth Observational Satellite, etc. These are presently being programmed for the 1979-1990 time frame and define the impact of these support requirements on network receiving and transmitting systems, the network control centers, and remote site computer and data handling systems.

W74-70728 **310-30-68**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
STATION MONITORING AND CONTROL TECHNOLOGY
G. A. Morris 213-354-2745
(310-10-64; 310-20-67; 310-30-60; 310-40-71; 310-40-72)

The general objective of this work is to increase the number of tracking station control and monitoring functions performed automatically without operator intervention. The goal is smaller tracking crews, reduction in pre- and post-calibration times, increase in good data acquisition, reduction in time to detect malfunctions, and to reduce the time to make operational substitutions to effect repair. The plans for FY-74 and FY-75 contain three types of activities: (1) the development of specific digital automatic control subsystems such as precision signal power measurement, receiver, transmitter, microwave, and antenna; (2) the development of wide bandwidth, high density telemetry recording to reduce tape utilization and avoid frequent reloading of recorders; and (3) the integration of several of these devices into a planetary radar interferometer to demonstrate two station tracking under realistic conditions. All of this work points toward a DSS-14 station automation demonstration in FY-76 using the DSS monitor and control subsystem for the coordinating computer. The development of subsystem automatic control will include the development of the microwave and antenna controllers which are new, and continuation of development on the transmitter, receiver, and precision signal power measurement equipment. All of these subsystems are planned to be implemented at DSS-14 with the DSN standard 14-line interface to achieve the FY-76 demonstration. The high density recording will have a goal of recording one pass of predetection signals from a station on a single reel of magnetic tape or film. The radar demonstrations are used to gather data for flight project planning and enhancement, to demonstrate hydrogen maser operational performance for two-station tracking, and to examine the operational characteristics of X-band for interplanetary communications and tracking.

W74-70729 **310-30-69**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
TRACKING STATION OPERATIONS TECHNOLOGY
Earl Jackson 714-288-8251
(310-10-60; 310-10-64; 310-30-68; 310-40-71)

This RTOP provides development and application of techniques of probabilistic and statistical analysis to the problem of an integrated logistic and station management system for the DSN. It also provides predicted ephemerides for use in the planetary radar program (performed under RTOP 68 - Station Monitor and Control Technology), and supports SRT activities at the Venus and Mars stations. Mathematical models describing spares issuance activity, shipping processes, inventory activity, maintenance performance and scheduling, and equipment and subsystem reliability will be developed and tested against actual and simulated data. The refined models will be used to develop, where necessary, new techniques of inventory and spares issuance, shipping, and maintenance performance scheduling. Utilizing a polynomial coefficient prediction program designated PLACE 1, predicted ephemerides will be computed on the Univac 1108 and utilized as control parameters in the planetary radar program. The accuracy of the predicted range and Doppler will be analyzed from the radar results and the corrections made available for development of more accurate planetary emphemerides for Mars, Jupiter, Saturn, Venus and the rings of Saturn. DSN development activities at Venus and Mars stations which will be supported by this RTOP include interferometeric planetary radar, long term development and testing of dual carrier techniques, station automation (to be demonstrated by remotely operating the Venus station from Pasadena during a pulsar observing track); and development and construction of X-band radar systems.

Data Handling and Processing

W74-70730 **310-40-25**
Goddard Space Flight Center, Greenbelt, Md.
AUTOMATIC COMPUTER PROGRAM DOCUMENTATION
E. P. Damon 301-982-6886

The purpose of this project is to implement an automatic system for computer program documentation. This system will produce timely, up-to-date documentation at relatively low cost. Initially, the system will be designed to accept FORTRAN, COBOL, PL/1, and Assembler languages. There will be no restrictions inherent to the design which will prevent it from being used to document other languages. It will be designed to operate on the IBM 360 with planned expansion to the Univac 1108 and the CDC 6600 computer system. All programs written for the automatic documentation system will be in a machine-independent language so that it can easily be moved from computer to computer. For the programmers who write programs in their own unique way, the automated system will be able to produce documentation such as detailed, detailed-suppressed, global flow charts, data layouts, overlay descriptions, etc. For programs developed outside this system, it will be fairly easy to retro-fit the program into the system for documentation maintenance.

W74-70731 **310-40-36**
Goddard Space Flight Center, Greenbelt, Md.
AUTOMATIC DATA HANDLING
John C. Rodgers 301-982-4189

Improvements to meet the large increases in support requirements demanded by NASA's future space programs specifically include a higher level of automation for Goddard Space Flight Center (GSFC) facilities resulting in increased data and information exchanges between the various GSFC facilities. This RTOP shall study methods of handling data and information and shall result in two end products: (1) the design and development of the Data Accountability System with the necessary capability to monitor, coordinate, and account for the data messages transferred between the remote ground stations and the GSFC facilities, and (2) variable exercisable computer simulation of the future data handling and processing capability at GSFC. The Data Accountability System shall interface with the M and DOD computer facilities and NASCOM concentrating on the particular problems inherent in data coordination, and

accountability when data is automatically transmitted between the ground stations and GSFC by computer to computer transfers. The computer simulation will aid in determining the requirements and design of systems to handle and process the data at GSFC. The simulation will also be an evaluation tool to determine where bottlenecks occur and what effect alternate changes have on the overall data handling system. The simulation can also be used in the evaluation of equipment proposals.

W74-70732 **310-40-38**
Goddard Space Flight Center, Greenbelt, Md.
COMPUTATIONAL SUPPORT
E. P. Greene 301-982-4123

A continuing need exists to reassess the functional capability of the M and DOD computer facilities in the light of present and future mission support requirements, advances in computer technology, and cost-effectiveness considerations. This RTOP contains four tasks designed to find practical answers to four aspects of this problem. In the first task the emphasis is on determining the practical guidelines and constraints which limit productivity on large computers operated in a multiprogramming environment. The second task is to develop the requirements and specifications to provide cost-effective computational terminals throughout this Center. In the third task an analysis of the computer complex within the Project Operation Control Centers will be performed to measure the computational workload of the various computers, identify processing bottlenecks where they may exist, and develop cost-effective replacements for these systems when necessary. The fourth task studies the archival properties of magnetic tape and other storage media in an attempt to identify the failure mechanisms and the factors influencing the useful life of the storage media, and to develop curative procedures for eliminating or reducing the adverse effects of these errors.

W74-70733 **310-40-39**
Goddard Space Flight Center, Greenbelt, Md.
IMAGE PROCESSING FACILITY PERFORMANCE EVALUATION AND IMPROVEMENT
J. Y. Sos 301-982-2841

The NASA Data Processing Facility (NDPF) is required to produce a large volume and variety of image data products of extremely high quality. This requirement places a very stringent demand on the equipment performance in the NDPF. It also limits for reasons of economy the number of types of standard products that can be generated. To assure achievement of high performance it is necessary to develop efficient performance monitoring techniques, parameters to characterize product quality, and obtain instruments to implement the techniques in conjunction with existing NDPF hardware. It is also necessary to study methods for generating image products that could be less expensive and more useful to the investigator, and to eliminate unneeded and expensive products. This plan proposes to develop efficient and accurate methods for monitoring and controlling performance of equipment, and assuring the quality and usefulness of products generated in the NDPF. The plan proposes to implement an image display and manipulation system (IDAMS) for support of the above activities.

W74-70734 **310-40-70**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
NETWORK DATA STREAM PERFORMANCE MONITORING AND CONTROL
R. J. McEliece 213-354-7058
(310-40-71)

This RTOP analyzes and improves the communication channel represented by the Ground Communication Facility (GCF), and provides technology for cost-effectively producing an error-free flight telemetry log at the NCS for flight project recall use. During FY-74, tests of the reliability of both the high-speed (4.8 kilobits/sec) and wideband (50 kilobits/sec) GCF lines were performed, and the resulting data are currently being subjected to extensive statistical analysis. Preliminary results of this analysis suggest that during normal operating periods the GCF channel can be quite accurately modeled by a three- or four-state Markov channel. It is expected that a final statistical model for the GCF lines will be settled on in FY-74; presumably it will be the Markov model mentioned above, but it is possible that a somewhat more complicated model will turn out to be necessary. This model will then be used in the search for a near-optimum data processing system for the GCF. The final system, which will be implemented in FY-76, could involve forward error-correction (possibly utilizing the extant 22- or 33-bit NASCOM error-detection code), an efficient feedback, i.e., error-detection and retransmission scheme, or a combination of the two. In any event it will be necessary to perform considerable research into the problem of finding the most efficient algorithms for performing the appropriate data processing. Additionally, it will be necessary to characterize as accurately as possible those relatively rare periods of GCF operation during which the noise is so severe that the signal cannot really be said to exist. The fraction of time during which the GCF lines are suffering from these outages represents an ineluctable lower bound on the fraction of the transmitted data which cannot be handled in real or near-real time.

W74-70735 **310-40-71**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
NETWORK CONFIGURATION MONITORING AND CONTROL
Richard R. Green 213-354-3015
(310-30-68; 310-30-69; 310-40-70; 310-40-72)

The objective of this RTOP is to develop optimum techniques for use in automating the monitoring and control of the DSN using high reliability control subsystems. This will reduce effects of operator errors on tracking missions, facilitate handling of multiple station and multiple spacecraft operations, and ensure high quality data especially during critical portions of missions. Toward this end, techniques for remote automatic control of network stations will be developed. Remote operation will be demonstrated by controlling a DSS-13 pulsar data gathering experiment from JPL. The XDS Sigma 5 computer at JPL will be used to control the gathering of the data. A typical data track will begin with the Sigma 5 computer transmitting programs to various computers at DSS-13, via teletype lines, to point and monitor antenna performance, configure and tune the receiver for the desired pulsar, and gather and analyze the pulsar data. The data will then be transmitted to the Sigma 5 for evaluation and any experimenter decisions as may be necessary. Further demonstrations in FY-75 will be conducted which will tie at least four DSS subsystems together and control a major tracking operation from JPL. To bring to the Deep Space Network the cost, performance, and reliability advantages of modern integrated circuits while maintaining a cost effective spares inventory, development of a set of high reliability standard logic modules will be undertaken. These modules will be constructed from screened MSI and LSI circuits which are available to JPL specifications from multiple vendors. The desirability of designing custom LSI circuits to fulfill specific performance requirements will also be investigated. If such custom LSI's are designed, multiple sources for the circuits will be found. These standard modules will be used throughout the DSN in the DSIF, the GCF, and the NCS.

W74-70736 **310-40-72**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
NETWORK CONTROL DATA PROCESSING
J. W. Layland 213-354-2757
(310-30-68; 310-40-70; 310-40-71)

The objective of this RTOP is to develop the techniques necessary to assess and accomplish DSN computational allocation, standardization and cost reduction. A greater understanding of the automatic computation process must be developed in order to do these jobs with the minimum cost and greatest efficiency. The abstract theory of computational complexity has been extended as a baseline for the measurement of computation requirements. Guided by the general complexity theory, a resource allocation analysis for computational resources is being developed which will define not only the amount of computation capability needed for a given job but also the most cost-effective balance between resource types. Tradeoffs between computational capability and communication requirements of the DSN computer

network, and between various computational elements of the multicomputer MiniNetwork that exists in the tracking stations or network control center, will be pursued. Methods, both managerial and technical, are being developed which will simplify the engineering and development of computer-based systems. These methods are to a great extent machine-independent, and defer the binding of design decisions to machine details until the latest possible time. The newly-emerging practice of Software Engineering and Structured Programming are applied to the machine-independent development of language processors for MBASIC, a flexible higher-level language which is itself designed to encourage Structured Programming. Machine-independent minicomputer software development techniques, and a programming-support system for minicomputers are being developed using the Sigma 5 computer. Such a system, together with hardware interface standardization, could permit limited sparing of one minicomputer type by another of comparable computer power, and thus simplify DSN logistics in lieu of complete hardware standardization of minicomputers. The design of a potential DSN standard minicomputer is being performed.

OFFICE OF MANNED SPACE FLIGHT

Advanced Development

W74-70737 **909-02-47**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
SHUTTLE SOLID ROCKET BOOSTER EXHAUST ENVIRONMENTAL EFFECTS
Paul J. Meeks 213-354-2546

The objectives of this RTOP are to characterize the large solid rocket motor (SRM) exhaust products and to determine the chemical interactions of these exhaust products in the atmosphere in order to provide data for the long range assessment of the environmental effects of shuttle SRM boosters. Programs within this RTOP encompass exhaust plume chemistry and exhaust-generated Al_2O_3 characterization. The programs are designed to supplement efforts by other NASA centers by concentrating in two specific areas: (1) providing initial source data (calculated profiles of aerosol formation and product composition and measured Al_2O_3 physical characteristics, concentrations, and size distributions) for the MSFC plume dispersion model and (2) investigating the effects of varying altitude on the formation, agglomeration, and dispersion of the SRM upper plume aerosol. During FY-74 the effort will include analytical modeling to allow predictions of the ultimate products formed in the SRM ground cloud and plume and their stability with respect to expected typical ranges in meteorological conditions. A subcontractor will carry out airborne monitoring (concentrating on the very fine Al_2O_3 size distribution) of the exhaust plumes generated by several solid rocket launches at the Western Test Range.

W74-70738 **909-04-04**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
ATTITUDE CONTROL PROPULSION
Paul J. Meeks 213-354-2546
(502-24-26)

The objective of this plan is to explore the basic design and operating characteristics of ignition devices based on the resonance tube concept, and to demonstrate the reliable operation of preprototype resonant ignition systems for hydrogen/oxygen propellants at temperatures down to about 100 K. The principles of resonant heating will be defined and established, and their application to ignition devices will be explored through analysis and experimentation.

W74-70739 **909-44-02**
Lyndon B. Johnson Space Center, Houston, Tex.
THERMAL CONTROL
W. W. Guy 713-483-2351

The objective of the proposed effort is to: (1) develop a modular, self-contained, inflatable radiator system that can be easily deployed in orbit from standard docking ports in order to minimize radiator area availability problems of future spacecraft; and (2) develop a modular, heat pipe radiator system which would replace conventional pumped-fluid radiators in order to improve performance capabilities, reduce system complexities, and possibly reduce weight. The approach in developing the inflatable, deployable radiator concept will include an analytical investigation and a feasibility test of candidate inflatable radiator concepts followed by the development of prototype hardware. This effort will utilize the technology base established by Echo balloons and other inflatable structures to develop a lightweight, inflatable radiator system. A modular, wide heat load range capability heat pipe radiator system will be developed by extending an on-going Grumman effort initiated in FY-72 in order to develop a more flight representative panel design configuration. Analytical design studies will be conducted prior to experimental verification of a three-panel modular heat pipe radiator system in a thermal vacuum environment.

W74-70740 **909-44-03**
Lyndon B. Johnson Space Center, Houston, Tex.
PROPULSION
Robert W. Polifka 713-483-4673

Generalized design criteria for acoustic resonator configurations utilizing a common entrance will be established and experimentally verified for the control or elimination of combustion instability having significantly different frequencies without the aid of injector baffles. The end product is the design and test verification of acoustic cavities capable of simultaneously damping the basic and higher tangential and radial modes of high frequency combustion instability. Recent testing has shown that the performance and stability of conventional high performance unlike impinging elements (doublets and triplets) are significantly effected by the heating up of the fuel in the jacket of a regeneratively cooled engine operating at moderate chamber pressures. Only nonconventional and like-on-like impinging elements have been shown to be applicable to the conditions of a fuel regeneratively cooled engine in the 100 to 200 psi chamber pressure range. The like-on-like elements require somewhat longer chambers to obtain high performance, and experience and understanding is lacking for unconventional elements. The objective of this effort is to understand the mechanisms that cause reactive stream separation, somewhat commonly called blow apart, for hypergolic propellants. In particular N_2O_4/MMH will be evaluated in single and multi-element hot firings under conditions consistent with advanced space engines such as the tug engine. A basic understanding of the problem associated with unlike elements operating with hot fuel is necessary if advanced high performing engines are to be developed at a reasonable cost.

W74-70741 **909-44-05**
Lyndon B. Johnson Space Center, Houston, Tex.
ELECTRICAL POWER
B. M. Stewart 713-483-4606

JSC specification SN-C-0046A outlines environmental and electrical screening test imposed on tantalum wet slug capacitors. The specification is designed to detect capacitors with marginal seals. Two major suppliers have stated that the random vibration screening requirements are potentially destructive in that they may cause damage to the anode lead riser and cause a catastrophic failure mode (open or short). A test program to assess the destructive potential of the vibration screen has been designed, and implementation might result in the elimination of a destructive and expensive screening test.

W74-70742 **909-44-07**
Lyndon B. Johnson Space Center, Houston, Tex.
COMMUNICATIONS
J. G. Sheppard 713-483-6301

This RTOP provides for increased communication and tracking subsystem productivity, reliability, and economy for the era of the 1980's. (1) Television subsystem design flexibility and reliability will be enhanced by developing solid-state components to replace certain relatively bulky and unreliable electromechanical compo-

nents presently in use. This will allow the multiple function usage of components inherent in good solid state design and reduce subsystem overall component count. (2) Subsystem productivity will be enhanced by developing new signal processing hardware. An example is a channel coding component in a minuscule LSI (large scale integrated circuit) package that triples the system capacity. (3) RF transmission will be enhanced by development of techniques to reduce losses (particularly at microwave frequencies) and conserve bandwidth, which both improves productivity and reliability. (4) RF tracking will be addressed by development of techniques to provide increased autonomy and lower the costs of tracking subsystems significantly. In all cases, the developments are designed to reduce system component count, which improves reliability, and lower costs of implementing systems. This is achieved by use of the burgeoning microcircuit technology in both digital and microwave areas, which allows maximum flexibility with minimum external interconnection.

W74-70743 **909-44-13**
Lyndon B. Johnson Space Center, Houston, Tex.
INSTRUMENTATION
Dave H. Owen, Jr. 713-483-4408

The corona detection effort is oriented toward the improvement of potential detection methods, other than those based upon EMI sensing, and is directed toward those detection methods to be utilized in ground test facilities. Results might also be of value for flight article utilization. As spacecraft design complexities and mission durations increase, cleanliness requirements become increasingly severe in regard to contamination, both molecular and particulate, of ultrasensitive components and systems, e.g., optical systems, thermal control coatings, etc. It is anticipated that the advanced technology to measure and identify chamber contaminants will eventually result in instrumentation with greater sensitivity, range, reliability, and lower total operating costs. Analytical and experimental studies will be performed to: (1) advance the technology, define and develop understanding of surface contamination mechanisms for specific detection methods and materials; and (2) define, develop and improve real-time measurement techniques for particulate contamination. Proof-of-principle hardware will be fabricated (where necessary), tested, and evaluated in the JSC laboratories. The Space Chamber Analyzer - Thermal Environment (SCATE) computer program should include analytical models of combined lambertian/specular sources often used to simulate IR irradiance for test vehicles or test subjects in space environment tests in the SESL of SETD. Techniques will be evaluated for combining program steps for efficiency, reducing memory requirements, and minimizing the complexity of converting the scate program to Exec 8 language.

W74-70744 **909-44-21**
Lyndon B. Johnson Space Center, Houston, Tex.
MANUFACTURING - INSPECTION
P. Moran 713-483-2941

The objective is to further develop methods of electrical termination techniques. These electrical termination techniques are to be utilized on the proposed Advance Aircraft Avionics Systems, Earth Resources Program, Department of Defense applications, unmanned and manned space efforts, and deep-sea oceanographic studies. This will necessitate improved materials and hardware integrity due to their intended extended usage on these programs, as well as the planned numerous flights. This program will identify the techniques which have the potential for joining, reworking, and inspection of various electrical conductors (copper, nickel, Kovar) in such configurations as the following: stranded copper with various platings to stranded; stranded to solid round with various platings; stranded to flat; flat to flat; flat to round; and round to round. The electrical conductors and terminations will be of various standard aerospace and commercial metals, platings, and dimensions. Under this program techniques will be developed which will expand existing techniques and give consideration to new methods in order to accomplish the above purposes. Equipment and hardware utilized in these techniques may require considerable time to develop; therefore, the necessity exists to initiate these activities as soon as it is feasible. It is anticipated that the utilization of this proposal will result in considerable JSC in-plant cost saving; e.g., establishment of facilities, equipment, and personnel which are not presently available.

W74-70745 **909-44-25**
Lyndon B. Johnson Space Center, Houston, Tex.
ADVANCED SCHEDULING
Robert Brown 713-483-4346

The objective of this study is to develop a capability for scheduling all resources of an advanced space program: as in the shuttle program, where launch frequencies are high, mission objectives are complex, and mission planning and support activities are numerous. Scheduling variables and program resources, such as payloads, vehicles, crew time, cost, and launch facilities, are interrelated and time dependent. Four subtasks are to be examined to provide understanding and software for the overall scheduling problem: (1) investigate the development of a scheduling language; (2) storage and retrieval of cost/tradeoff data; (3) develop a traffic optimization algorithm; and (4) investigate definition of schedule priority systems. This RTOP will be initiated in FY-73 through competitive procurement, and the first year's effort has been partially funded through FY-73 obligation. The remainder of the first year effort and a portion of the second year effort are proposed for FY-74 obligation, as shown on the attached resource requirement sheet.

W74-70746 **909-44-26**
Lyndon B. Johnson Space Center, Houston, Tex.
ALGORITHM DEVELOPMENT
D. Jezewski 713-483-3532

The purpose is to examine integer linear programming algorithms capable of rapidly solving large dimensional problems yielding integer solutions. A complete literature search would be made and any new developments documented where appropriate. The final product would be one or more algorithms capable of solving either specific problems or classes of problems encountered in operations support of future programs.

W74-70747 **909-44-27**
Lyndon B. Johnson Space Center, Houston, Tex.
ADVANCED SOFTWARE DEVELOPMENT
Victor Bond 713-483-3946

In the past few years, two of the leaders in development of orbit theory were able to apply a linear transformation for the first time to the classical orbital elements used to describe a space trajectory. These men, Drs. Kustaanheimo and Stiefel, had performed a transformation which mathematicians had failed to do for centuries. Their theory, therefore, was named K-S theory after their efforts. A four-dimensional transformation has been made into a function space where linear sets of differential equations were produced for the motion of a body in a multiplanet system, instead of the usual nonlinear expressions which take exhorbitant amounts of computer time to solve by iterative techniques. Thus, the K-S subroutine, is expected to save computer time while improving computational accuracy. This study for NASA-JSC was initiated in March, 1973, for the purpose of integrating the K-S theory into existing trajectory subroutines. Dr. Gerhard Scheifele, a former student under the originators of K-S theory, has extended their techniques and principles into a new method that uses an analytical transformation, instead of their numerical approach, and this new method will be applied to synchronous orbit theory.

W74-70748 **909-44-28**
Lyndon B. Johnson Space Center, Houston, Tex.
SOFTWARE PROCESSES
Linda R. Kirbie 713-483-3281

The need for GDMS (generalized data management systems) is apparent in Government installations and the military because of the need to process large volumes of data quickly and to satisfy the requirement for rapid response to a variety of queries from several data bases. The traditional methods of developing new computer programs with individual data bases, which cannot be transferred to another computer system and accessed in a different manner, are costly and impractical. It is costly because today's storage devices permit integration of the data which permits multiple applications to use and share the same data

without the need for redundancy. It is impractical and undesirable because it does not permit several different data bases to be accessed and manipulated without user concern as to data content and structure. Other motivations for utilizing GDMS for certain classes of applications are: drastic reduction in the programming effort and time to get a job running; permits nontechnical personnel to interface with the data; provides both generality and flexibility in the building and manipulation of data structures to the degree of complexity necessary for individual applications; and a marked decrease in the amount of effort to respond to changing requirements.

W74-70749 **909-44-29**
Lyndon B. Johnson Space Center, Houston, Tex.
COMMUNICATIONS/NAVIGATION/TRAFFIC
B. H. Batson 713-483-5566

This RTOP covers work in areas related to digital communications signal processing and transmission techniques for voice, data, commands, and digital television channels. Communications systems for future generations of manned and unmanned spaceflight programs must be capable of transferring larger amounts of information, while the associated hardware must be more reliable, lower in cost, etc. Various digital processing techniques, including source encoding (data compression) and channel encoding (forward error control) will be required in order for these criteria to be satisfied. Considerable preliminary work has already been performed in these areas. For example, in-house tests using a digital test set (DTS) developed under FY-71 RTOP funds have verified the effectiveness of several of the less sophisticated source and channel encoding techniques, but have indicated certain optimization procedures will be required to realize the full theoretical improvements promised by digital communications theory. In addition, the need for more sophisticated source encoding techniques for low-rate digital television transmission (involving line-to-line and frame-to-frame correlation) has become apparent for advanced-type system applications. The approach followed will be to concentrate on signal processing and transmission techniques which are potentially realizable in hardware implementations. Whenever applicable, modifications to existing breadboards will be designed and installed, thereby providing a means for inexpensive experimental evaluation of the techniques and hardware under consideration. This approach will provide for a firm base from which spacecraft and ground systems can be specified.

W74-70750 **909-44-31**
Lyndon B. Johnson Space Center, Houston, Tex.
SPACE OPERATIONS TECHNIQUES
Sam Mayfield 713-483-4491

A study has been obligated in FY-72 to determine a consumables management philosophy using automated techniques with the space shuttle as the design baseline. The product of this study is to develop a matrix of consumables management concepts from which a tradeoff analysis can be conducted and a final selection made. The proposed task would take the matrix and apply its general results to a specific system design for automated or semi-automatic management of onboard consumables for future spacecraft. The final concept will then be analyzed to determine functional requirements for on-board systems and their associated instrumentation which relate to consumables management. The generalized results of the present contract will be applied to the specific task of relating mission and system requirements for the family of manned missions to a viable automated management concept and performing tradeoff studies to minimize impact of system designs and crew activity requirements. Finally, the results of the proposed study will be expanded to provide a generalized management concept for future manned vehicles as an advance of the operations state-of-the-art, including second-generation shuttle vehicles and missions.

W74-70751 **909-44-35**
Lyndon B. Johnson Space Center, Houston, Tex.
SYSTEMS ENGINEERING APPLICATIONS
Humboldt C. Mandell, Jr. 713-483-2741

The objective is to improve JSC and NASA capability to use costs and schedules as parameters in avionics system design and development. The approach is to: (1) develop an avionics data base of historical cost, schedule, and technical performance characteristics which are capable of producing statistical inferences for future hardware developments; (2) to use the data base developed for each subsystem in determining relationships between cost, schedules, and readily-known parameters, such as desired technical performance characteristics; (3) to perform cost and schedule sensitivity analysis over state-of-the-art and advanced (expected) performance ranges for each subsystem; (4) to verify the validity of cost and schedule estimating techniques developed with an example from each subsystem family, within the relevant performance ranges mentioned in (3); and, (5) to determine the influence of cost related parameters on advanced avionics system designs. Special studies will be performed to investigate low cost approaches to avionics development. These will include investigations of the use of previously-developed subsystems, and the relaxation of NASA specifications to ARINC standards and the use of commercial fabrication and testing techniques. Investigations will include the study of least costly lot sizes for the purchase of NASA avionics equipment.

W74-70752 **909-44-36**
Lyndon B. Johnson Space Center, Houston, Tex.
MECHANICAL SYSTEMS
Richard F. Smith 713-483-3791

The U.S.A. and U.S.S.R. will discuss in FY-1974 ways and means of achieving compatible redezvous and docking between future spacecraft. International-type discussion on the ways and means for joining spacecraft must begin soon. Past discussions have shown that agreements can be reached only when the credibility of proposals from a particular country are supported by engineering analyses, test data and, often times, demonstration articles. The purpose of this RTOP to fund those analyses, tests, and hardware necessary to allow the U.S.A. to make technical judgments to assure the credibility of its proposals. The areas covered are: electromechanical attenuators; pressure seals; mechanically and manually mated electrical, hydraulic, and pnuematic interface connectors; semicompliant tunnel extension bellows; structural latches and latch verification devices; and electromechanical actuator technology.

W74-70753 **909-44-37**
Lyndon B. Johnson Space Center, Houston, Tex.
CRYOGENICS
R. K. Allgeier 713-483-4771
(908-42-32)

A design and manufacturing effort has been concluded which resulted in an 800 cubic ft. liquid hydrogen tank. This Dewar embodies a sophisticated double shield insulation concept, a complex support heat shorting design, and rapid pressurization and repressurization capability for high expulsion rates. However, funding limitations to date have prevented any testing other than electrical and mechanical functional checkout. The overall program objective is to provide verification, through testing, of the new technology embodied in the vessel.

W74-70754 **909-44-38**
Lyndon B. Johnson Space Center, Houston, Tex.
MATERIALS
F. S. Dawn 713-483-4701

The objective is the advancement of the production and application technology organic materials that will not support combustion. The materials developed will be suitable for aircraft and other uses because of its durability, flexibility, abrasion resistance and physiological compatibility to satisfy low cost usage requirement. A copolymer of chlorotrifluoroethylene has been developed as the best polymer system based on durability and flame resistant characteristics. The material self-extinguishes in oxygen enriched environment without the use of any fire retardant and produces practically no smoke. An extension of the application of low cost nonflammable elastomeric polymers to replace the expensive fluorocarbon elastomers presently used in applications requiring flame resistance is highly desirable. Fire retarding technology will be applied to existing low cost elastomeric polymers (particularly silicones, urethanes, and neoprenes) to obtain a class of inexpensive nonburning elastomeric systems

capable of meeting a wide range of durability and operational requirements. The compatibility of presently available novel high-strength organic fibers as reinforcing members in polyimide resin matrices will be evaluated. Laminate constructions, laminating pressures, cure schedules, and processing procedures will be optimized to increase strength-weight ratios over present polyimide laminates which incorporate glass fibers.

W74-70755 **909-44-39**
Lyndon B. Johnson Space Center, Houston, Tex.
AEROTHERMODYNAMICS
William C. Moseley 713-483-2237

This effort is designed to provide current state-of-the-art technology studies in support of engineering design analysis of space vehicles. The effort will continue the development of the Optimal Design Integration (ODIN) computer program system capability so that preliminary design activity can be performed by computer. The continued development of ODIN will involve the integration of key subsystems elements in the repertory of technology modules and special utility functions to allow uniform design simulation.

W74-70756 **909-54-07**
Marshall Space Flight Center, Huntsville, Ala.
COMMUNICATIONS
D. O. Lowrey 205-453-1578
(909-51-07)

The objective of this effort is to develop an S-band electronically steerable microwave phased array system for space communications and tracking purposes. This system will provide a high data rate, telecommunications capability with simultaneous or separate transmit, receive and tracking functions. Considerable system performance improvement with decreases in size and weight will be realized over the conventional systems using transmitters, receivers, antenna, transmission lines, control and driving motors and associated supporting structures. This is a continuing effort that will produce a phased array that is lightweight, highly redundant, has low direct current drain, uses 100 percent integrated circuitry and utilizes a building block construction concept for maximum design versatility and minimum cost. The study of the application of active electronic modular techniques to a Ku-band electronically steered phase array will continue.

W74-70757 **909-64-09**
John F. Kennedy Space Center, Cocoa Beach, Fla.
ABORT AND SAFETY
Wallace H. Boggs 305-867-2102

Recent tests conducted at the Kennedy Space Center to verify the existence of the autoignition phenomena in cryogenic propellants mixed in the atmosphere produced statistical evidence of a threshold effect, beyond which ignition and explosion become increasingly certain. These tests were not designed to be quantitatively precise in the measurement of the processes involved in the autoignition, but rather to observe macroscale explosive intensity and propagation parameters. In order to obtain a more complete definition of the autoignition process, which will aid in explosive hazards estimation, it is proposed to perform laboratory scale instrumented observations of the parameters involved in the mixing and boiling when cryogenic fuels and oxidizers are brought together. A description of the processes which lead to autoignition, with parameters, forcing and controlling functions defined, is the desired objective.

W74-70758 **909-64-38**
John F. Kennedy Space Center, Cocoa Beach, Fla.
MATERIALS
M. G. Olsen 305-867-3477
(908-62-09)

The objective is the continuation of work now underway to characterize a selected group of materials as to their reactivity in high pressure gaseous oxygen and liquid oxygen. A new series of tests with mixed gaseous nitrogen and gaseous oxygen will also be conducted. In addition, the effort will establish correlation between the different methods used at WSTF, MSFC, and KSC for testing materials in oxygen. The effort is conducted in-house and will involve continued evaluation of current literature together with laboratory and field test of new materials.

W74-70759 **909-74-35**
Langley Research Center, Langley Station, Va.
INTEGRATED POWER/ATTITUDE CONTROL SYSTEM FOR SPACE VEHICLE APPLICATIONS
Eugene S. Love 804-827-2893

This work will establish the required technology for an Integrated Power/Attitude Control System (IPACS) capable of performing the dual function of power generation and attitude control for a large variety of spacecraft and missions. Results from in-house and contractual efforts are being used to investigate power generation and control capability of IPACS; to generate requirements for critical hardware components; to develop IPACS configurations and control laws; and to define multimission applicability of IPACS to provide low cost modularized vehicle subsystems. Viability of the IPACS concept will be verified through integration of critical hardware components into a laboratory IPACS and through thorough evaluation of this unit in a realistic mission and dynamic environment using LRC static and dynamic test facilities. Associated development programs will be directly coordinated with LeRC, GSFC, MSC, and MSFC. Preliminary problem areas include the impact of reliability, maintainability, failure modes, and system integration on IPACS performance and multi-mission usage capability; performance limits of composite materials under cyclic stresses and extended-duration vacuum; development of bearings, seals, and lubrication systems capable of long-life at high speeds and under large cyclic loads; development of high power, high-efficiency motor generator units for operation at high speeds; development of high-power, long-life, low friction slipring assemblies for operation in a vacuum. Solutions to these problems will be verified through hardware tests and simulations, which will determine power generation capability, control effectiveness, and spinup, spindown cycling effects on system performance. Successful and timely completion of this program could result in significant cost savings resulting from large weight and volume savings and multi-mission usage of an IPACS module.

W74-70760 **909-54-33**
Marshall Space Flight Center, Huntsville, Ala.
INFORMATION MANAGEMENT SYSTEMS (SUMC AND TUG)
H. Garrett 205-453-4070

The objective of the SUMC effort is to develop advanced space computer hardware, software, and peripheral devices. Also development of computer/scientist languages and interactions will be performed. This effort will lead to the development of advanced space computers, multiprocessors, and multicomputer systems, and the associated software; development of advanced computer peripheral devices such as displays, history plotters, keyboards, hard copy devices, and mass storage units; and development of high level computer/scientist languages to facilitate man-machine interaction. The objective of the tug effort is to define, develop, and qualify an on-board information management system which can best accomplish the requirements of the space tug missions. Areas in which analyses and technology developments are required will be identified. The requirements for memory will be determined and an effort initiated to provide a reliable mass storage capability for space tug with emphasis upon reliability within reasonable cost. In addition, development testing sufficient to provide for confidence in the space ultrareliable modular computer (SUMC) for a tug type space application will be undertaken.

W74-70761 **909-55-01**
Marshall Space Flight Center, Huntsville, Ala.
STRUCTURAL
J. H. Farman 205-453-4346

The objective is to provide the technological basis, in the area of structures, for the development of new and/or improved design criteria, strength analysis, dynamic analysis, and test methods appropriate to the space tug vehicle. Emphasis will be on technology improvements needed for unique tug mission requirements, configuration, and environment. Areas of technologi-

cal concern are vehicle reuse, minimum weight structural systems, refined optimization techniques, refined strength analysis techniques for lightweight structural systems, and refined structural dynamic analysis techniques for the prediction of transient and quasi-steady state dynamic loads and longitudinal stability margins (POGO). The objective here is to establish design, analysis, fabrication, and inspection techniques to provide lightweight, reliable structural systems, to investigate the optimum designs for thin-walled and unpressurized structural components, to demonstrate the use of advanced composite materials for application to representative space tug structural components, and to develop reliable meteoroid shielding for the space tug propellant tanks; and other systems. The approach will include material evaluation, design, fabrication, and test of major structural components applicable to the space tug vehicle. Lightweight and highly reliable structures will be emphasized.

W74-70762 **909-55-02**
Marshall Space Flight Center, Huntsville, Ala.
THERMAL CONTROL
J. L. Vaniman 205-453-3821
(909-51-02)

Thermal control of the tug is defined as the maintenance of thermally sensitive tug equipment and structures within specified critical temperature limits through the control of heat flow to and from such equipment. Equipment includes such items as astrionics, fuel cells, APS systems, and hydraulic systems. It does not include thermal isolation and conditioning of main propellant tanks which is covered under a separate RTOP. Thermal control is required during all mission phases including prelaunch, ascent, orbital maneuvers, descent, and landing. Early studies have shown that totally passive thermal control will not provide required thermal conditions throughout the broad range of environments encountered within the tug mission profile. Semipassive, integrated, and active thermal control systems are required. The objective of this RTOP is to provide the development of necessary systems and system elements for meeting tug requirements, and to demonstrate tug application feasibility and benefit through demonstrations by breadboard development and testing. Such elements must be developed to perform their required functions at minimum weight, a critical tug parameter, and at the least practical power requirement and cost. This program was initiated in FY-73 and should be completed in the 1975-1976 time frame.

W74-70763 **909-55-03**
Marshall Space Flight Center, Huntsville, Ala.
PROPULSION
K. W. Gross 205-453-3815
(113-31-51; 113-31-12)

The objectives of the effort described here are to develop an analytical turbulence model coupled with chemical kinetics and mass addition which will replace the present semiempirical formulation used for rocket thrust chamber boundary layer analyses, and to complete the fabrication and delivery of hydrogen and oxygen low speed pump inducers compatible with the RL-10 engine turbomachinery. The present turbulence model will be modified to include finite chemical reaction rates coupled with boundary layer mass addition. The analytical solutions obtained will be compared with test results. The low speed inducers have been designed to operate with the RL-10 turbomachinery at zero tank NPSH and fabrication is in progress. FY-74 funds will complete the procurement.

W74-70764 **909-55-05**
Marshall Space Flight Center, Huntsville, Ala.
ELECTRICAL POWER
R. M. Aden 205-453-4950
(909-51-05)

The effort described in this RTOP is in support of the space tug in the electrical power area and is divided into four tasks: rechargeable batteries, feed thru electrical connectors, component development, and fuel cell development. Development of rechargeable silver-zinc batteries will continue. The objective is the development of a 300 amphere-hour rechargeable Ag-Zn battery capable of 1 year wet-stand life, 50 cycles at 50% depth-of-discharge, and an energy density of 55 watt hours/lb. (100% D.O.D). The feed thru electrical connector effort will continue to develop improved connectors for the space tug. The requirements dictate connectors that will have long life at low leakage rates, with repeated cycling from ambient to cryogenic temperatures, with penetrations through thin tank walls, and will include both conventional and coaxial connectors. Selected tug components to be evaluated will include switch gear, circuit protection, cable, connectors, docking motors, and motor control schemes. The objective is to provide components that have longer life and are cost and weight effective for tug use. Efforts will begin on the development of a tug fuel cell as a primary power source. The objective is a 1-Kw fuel cell power plant based on shuttle technology. Design goals include total life capability of 5000 hours, a capability of 100 restarts, and a weight of approximately 15 kg. (35 lbs.)

W74-70765 **909-55-10**
Marshall Space Flight Center, Huntsville, Ala.
GUIDANCE AND NAVIGATION
J. D. Ellsworth 205-453-4583
(502-23-42; 909-55-05)

The effort described in this RTOP is the advanced development in the area of guidance and navigation for the purpose of establishing an adequate technology base for the tug. The two tasks are: (1) laser gyro strapdown inertial measurement unit and (2) the scanning laser radar. The laser gyro strapdown IMU will be developed for a full capability tug and be based on prior technology efforts. This redundant system will consist of six laser gyros and six pendulous accelerometers in a dodecahedron arrangement interfaced with a SUMC computer. Efforts will continue to develop a prototype scanning laser radar with specific improvements in weight, range, scanning accuracy, reliability and effeciency, which can be space qualified and which will provide range and angle information to meet the tug rendezvous and docking requirements.

W74-70766 **909-55-21**
Marshall Space Flight Center, Huntsville, Ala.
MANUFACTURING AND INSPECTION
R. M. Henritze 205-453-1426

The objectives of this effort are to evolve, through advanced development and technology applications studies, new inspection techniques required for effective inspection of space tug hardware, structures, and systems. In-process inspection and end item inspection techniques employing nondestructive testing concepts, process control concepts, and visual inspection concepts are to be studied and developed to provide the techniques required by the program. Inspection techniques required during production and prelaunch operations are of primary interest; however, their applicability to post-launch in-place monitoring of the integrity of structures and systems hardware will also be considered. Increased capability, reliability, and accuracy over existing inspection techniques and reduction of dependence on man's direct involvement in transaction of data are key objectives. Through studies of the structures, materials, systems, and hardware proposed for the program, the inspection requirements and techniques necessary to assure quality, per prescribed design, will be identified. These requirements will be compared to existing techniques and, where existing techniques are found insufficient, new techniques will be developed or further development performed to advance existing techniques. Certain shortcomings existing in program applicable nondestructive testing techniques can be readily identified. Initial efforts will be oriented to these more obvious shortcomings.

W74-70767 **909-55-37**
Marshall Space Flight Center, Huntsville, Ala.
CRYOGENICS
A. L. Worlund 205-453-3853

The objective is to demonstrate the required cost, weight, and thermal performance of the tug cryogenic propellant systems that will be capable of satisfying the system interface and environmental parameter. This plan will integrate the required technology advances for an earlier feasibility demonstration of the interim tug propellant system, and will identify problem areas

and provide the technology base for assessment of a full capability tug module. The development of design details and operating procedures will be a principle output of these efforts. The prime emphasis will be to adapt advances developed under prior technology programs which have not been applied to flight vehicles but which have been adequately proven through conceptual tests or hardware development.

W74-70768 **909-55-38**
Marshall Space Flight Center, Huntsville, Ala.
MATERIALS
W. A. Riehl 205-453-1280
(909-55-01)

Graphite-aluminum composites will be developed using the continuous mechanical forming technique to achieve low cost components. This work is expected to combine the advantages and eliminate the disadvantages of currently available composites: graphite epoxy and boron-aluminum. The feasibility has been established overcoming the longstanding difficulty of fiber deterioration which has occurred when graphite was heated in a metallic matrix. Proper metallic coating of the fiber provides the key to compatibility and high bond strength. Following process technique development, specimens will be produced and properties, including tensile, fracture toughness, fatigue, and thermal limits, will be determined for use by designers of spacecraft structures. Materials support will focus on: (1) development and characterization of new light weight aluminum alloys, (2) development of updated outgassing criteria for materials, and (3) fracture mechanics of materials in storable propellants.

W74-70769 **909-55-40**
Marshall Space Flight Center, Huntsville, Ala.
AEROELASTICITY (DYNAMICS)
Robert S. Ryan 205-453-2481

This RTOP describes the program of research and technology to be undertaken in the areas of docking dynamics, uncooperative docking, remote controlled docking, large amplitude slosh, transient liquid motion, and structural dynamics as related to vehicle control. The objective of these efforts is to secure advances in the state-of-the-art in the areas specified above to support the initiation of design and development of a tug or similar spacecraft. The approach is to conduct several studies of closely related in-house (both at MSFC and other NASA centers) and contracted tasks aimed at specific improvements in methods and development techniques with the ultimate goal(s) of improved performance, weight, and reliability characteristics.

W74-70770 **909-75-03**
Lewis Research Center, Cleveland, Ohio.
ADVANCED H2-O2 ENGINE TURBOMACHINERY TECHNOLOGY
J. W. Gregory 216-433-6849
(502-24-31)

The objective of the efforts under this RTOP is to provide improvements in the technology of the turbomachinery applicable to advanced, high performance reusable hydrogen-oxygen rocket engines. Such engines must operate reliably in space for long periods of time and provide many restarts during a minimum of 20 missions. Included in this program are efforts on components of turbopumps as well as complete turbopump assemblies. Technology will be developed for long life, small, high speed bearings for liquid hydrogen turbopumps. Both rolling element and hybrid (fluid film) bearings of 20 millimeter size (shaft diameter) will be evaluated. Bearing design and fabrication will be provided under contract, and bearing testing will be performed in-house at LeRC. Effort will also be applied to the design, fabrication, and testing of controlled fluid film seals for small, high speed liquid oxygen turbopumps. This contract effort will evaluate seals of 30 millimeter diameter capable of 10 hours operational life and 300 start/stop cycles at shaft speeds up to 90,000 rpm. Work will be initiated in FY-74 on the testing of a complete liquid hydrogen pump assembly designed and fabricated under FY-73 funding. The pump will be capable of providing discharge pressures up to 4500 psia and will operate at shaft speeds up to 120,000 rpm. Testing of the pump will be completed to obtain performance maps, evaluate critical speed problems, measure leakage flows, determine transient behavior, and investigate off-design point operating characteristics.

W74-70771 **909-66-34**
John F. Kennedy Space Center, Cocoa Beach, Fla.
LAUNCH FACILITIES AND EQUIPMENT
D. Nail 305-867-6328

The objective is to study the existing KSC RF Operational Intercommunications System (OIS-RF) which provides constant, selectable, voice communications for test and operations personnel located in launch and industrial area facilities. The study will make recommendations for the automation or simplification of OIS-RF test, checkout, and verification. The study effort will investigate operational and maintenance requirements to determine the degree and type/philosophy of automation. Recommendations for automation will result in improved ease of operation, reduced maintanance, repair, and alignment time with improved reliability to reduce potential impact to test and checkout of future space vehicle systems.

W74-70772 **909-66-37**
John F. Kennedy Space Center, Cocoa Beach, Fla.
CRYOGENICS
F. S. Howard 305-867-8081
(908-67-40)

The objective of this task is to provide a two-phase flow computer model of a liquid hydrogen (LH2) transfer system to provide a design tool for LH2 systems used in support of future programs. Utilization of this design tool will result in reduced LH2 loading times, and the prevention of operational anomalies. Development of this model would be accomplished in the same manner as the LO2 system model developed for the Kennedy Space Center previously by the National Bureau of Standards.

W74-70773 **909-67-18**
John F. Kennedy Space Center, Cocoa Beach, Fla.
CHECKOUT
R. C. Leonard 305-867-5444

The proposed work will investigate one possible method of implementation of high-level computer languages used in support of future launch operations. Microprogramming will be considered as the means by which the intermediate form of the language may be directly executed, thus providing a versatile and efficient system architecture. This study will gather and evaluate information related to similar languages implemented in this fashion, and recommend techniques which seem to be most applicable for the launch operations environment. It will attempt to show how the flexibility and efficiency of this method can lead to reduced development and operations costs.

Space Life Sciences

W74-70774 **970-21-11**
Ames Research Center, Moffett Field, Calif.
NEUROPHYSIOLOGY
H. P. Klein 415-965-5094
(970-21-11; 970-21-53)

The objective of this work is to determine the effects on the nervous system of the unusual environmental factors encountered in space. This information will be applied in the evaluation, prediction and control of adverse effects resulting from exposure, for example, to high and low 'g' forces and unusual linear and angular forces. Particular attention will be paid to: (1) vestibular, visual and proprioceptive systems, (2) their anatomical substrates, (3) their interactions, and (4) their relationships with the arousal mechanisms underlying sleep and wakefulness. Descriptive studies will define the influences of altered gravity on neurophysiological functions, orientation, sensorimotor coordination postural control and locomotion. Analytical studies will be devoted to the understanding of the neural processes involved in the reception of gravitational stimuli, thresholds for detecting changes in acceleration and rotation, and the rate and level of adaptation to chronic exposure

to altered gravity. In addition, studies will address the mechanisms which underlie changing levels of sleep and arousal, attention, altertness, and motivation in the presence of the gravitational and accelerative forces encountered in space flight. Other sensory systems such as those serving auditory and cutaneous (tactile, thermal and pressure) sensibilities will be investigated as necessary in support of flight experiments and in developing basic information relevant to remotely operated systems.

W74-70775 **970-21-12**
Ames Research Center, Moffett Field, Calif.
CARDIOVASCULAR-PHYSIOLOGY
H. P. Klein 415-965-5094

The objectives of this program are to describe and understand the course of adaptation of the cardiovascular system to space flight conditions and its readjustment to normal gravity upon re-entry to earth's environment. Work will be conducted in both animals and man. Human studies will be accomplished during bed rest simulations of weightlessness using primarily non-invasive, non-destructive testing methods. Animal studies will be performed in appropriately instrumented chronic animal preparations. Studies to date have demonstrated that both central (cardiac) and peripheral vascular mechanisms are contributing to the altered orthostatic response after bed rest and associated decreased tolerance to plus Gz acceleration profiles. Continued ground-based studies are being utilized to determine extent and time course for observed changes and their implication in development of selection criteria for future passengers aboard space flight missions.

W74-70776 **970-21-13**
Ames Research Center, Moffett Field, Calif.
RESPIRATORY PHYSIOLOGY
H. P. Klein 415-965-5094

It is predicted that pulmonary function changes significantly in weightlessness. The objective of this program is to determine the magnitude of certain of these changes and determine their effects on the ability of man to adjust successfully to long duration spaceflight and to readjust to normal gravity subsequent to such a mission. In addition, the part played by gravity in determining pulmonary function on earth in health and disease will be examined on subjects and patients to obtain baseline data and improve the prediction which can be made regarding the changes expected in weightlessness. The functions being measured are lung volumes, oxygen and carbon dioxide washout, regional perfusion, regional ventilation, total ventilation, ventilation/perfusion ratio for whole lung and different regions, pulmonary diffusing capacity, mixed venous CO2 tensions, pulmonary blood volume and cardiac output. In the area of aerosol deposition experiments have been carried out under high and zero gravity conditions and have confirmed the predicted changes in deposition in the lung from the larger particle sedimentation factor. The approaches include: (1) investigations to determine the effects of gravity on normal human lung, with particular reference to mechanical deformation and its effects on pulmonary function; (2) continued work on baseline data on patients with early pulmonary disease; (3) feasibility demonstrations for hardware systems for testing pulmonary function; and (4) aircraft parabolic flight experiments to evaluate aerosol deposition changes under varying g loads.

W74-70777 **970-21-14**
Ames Research Center, Moffett Field, Calif.
METABOLISM AND NUTRITION
H. P. Klein 415-965-5094

Studies of blood and urine samples subsequent to space flight and during bed-rest simulations of weightlessness have demonstrated an altered metabolic and nutritional state. The objectives of work in this area are directed towards obtaining a greater understanding of the regulatory processes leading towards these changes. Research is conducted in carbohydrate and fat metabolism; calcium metabolism and factors influencing the physical integrity of bone; work performance heat production, and temperature regulation; water and electrolyte metabolism; liver function tests; and remedial measures to offset effects of adverse acceleration environments. Work is performed using both experimental animals and human test subjects. Approaches are oriented towards ultimate applications to human maintenance diagnosis, prevention, and physiologic factors bearing on mission safety requirements with special emphasis on the effect of acceleration environments.

W74-70778 **970-21-16**
Ames Research Center, Moffett Field, Calif.
ENDOCRINOLOGY
H. P. Klein 415-965-5094

The general objective is to define more precisely the endocrine mechanisms which mediate the physiological responses and adaptations encountered in prolonged space flight. Research will be primarily directed to the analysis of the endocrine mechanisms regulating protein, lipid and mineral metabolism. Emphasis will be placed on the development of biochemical methods for assessing the endocrine status of subjects exposed to prolonged space flight with particular reference to the effects of real or simulated weightlessness and of variable g-forces. The specific approaches to be employed are as follows: (1) the quantitative determination of the levels of circulating pituitary and other peptide hormones in plasma; (2) the analyses of the spectrum of tissue peptidases involved in the conversion of peptide hormone precursors into biologically active hormones as well as their involvement in regulation of the biologically active concentrations of pituitary and other peptide hormones; (3) analysis of the effect of variable g-forces on the plasma concentrations of peptide hormones and their resultant effects on protein, lipid and mineral metabolism; (4) evaluation of radiorespirometry as a tool for assessing the endocrine-dependent metabolic status of the whole animal; (5) analysis of endocrine-dependent enzymes involved in lipid metabolism and transport and (6) the elucidation of the effect of varying brain serotonin levels on responsiveness of the pituitary adrenal system to stress.

W74-70779 **970-21-25**
Ames Research Center, Moffett Field, Calif.
CHEMISTRY AND MICROBIOLOGY
H. P. Klein 415-965-5094

The objectives are to define and study the potential microbiological and biochemical problems of manned space flight. Studies will be directed to examine and assess alterations between man and his microflora in the spacecraft environment during manned space flight, especially as they may adversely affect astronaut health. Research will be oriented toward a number of parameters concerned with virulence of microorganisms, immunity to infection, rapid diagnosis of the infected state, measures to prevent or limit infectious disease, microbial shock and mutational effects as related to manned space missions. The overall approach will be to study the mechanism of responsibility for undesirable or hazardous changes in the host parasite system in a spacecraft environment, mainly by a continuation and expansion of grants to universities plus specific in-house efforts.

W74-70780 **970-21-35**
Ames Research Center, Moffett Field, Calif.
ENVIRONMENTAL FACTORS EFFECTS
H. P. Klein 415-965-5094

The objectives are to determine effects of various environmental factors (atmospheric contaminants, weightlessness and Gz) in relation to human performance and health in spaceflight. Cellular consequences as well as physiological effects will be studied. Human particulate induced pathology is being studied as a point of reference with respect to the state of damage which may occur in astronauts exposed to particulate matter in the weightless state. Correlations are being made between morphological alterations and physiological changes caused by agents contaminating the atmosphere or by other environmental factors. Extent of damage and extent of reversibility is being ascertained using ultrastructural morphology as an endpoint. Since resistance to respiratory infection may be altered under spacecraft conditions, changes in resistance will be studied also. Design limitations predicate that crew and passengers on space vehicles will be subjected to weightlessness for considerable periods of time during spaceflights. Tolerance of humans after varying periods of simulated weightlessness will be determined under medically controlled conditions. The effects of weightlessness and reentry

profiles from the weightless state will be ascertained in a wider variety of subjects as may be candidates for passengers in the shuttle.

W74-70781 **970-21-45**
Ames Research Center, Moffett Field, Calif.
MEDICAL SUPPORT
H. P. Klein 415-965-5094

The objectives of this program are to study environmental influences on the efficiency of specific drugs likely to be used during manned space flight. Emphasis will be placed on determining adverse or beneficial reactions because of altered absorption or metabolism of the drug in the space environment or because of specific synergistic or antagonistic effects of the drug to physiological changes produced by weightlessness and other flight factors. Work will also include the assessment of possible interference of chemotherapeutic agents likely to be employed during manned space flight with routine physiological and biochemical determinations used to evaluate health status. The interaction of aspirin and other drugs with various stresses and altered hormonal levels on body temperature, ulcer formation, serum electrolytes and bone demineralization will be evaluated. Experiments in primates (rhesus) will determine the effects of simulating weightlessness by restraint, exposing them to 7-12 torr CO2 and administering aspirin daily, and on uric acid excretion and bone mineralization.

W74-70782 **970-21-51**
Ames Research Center, Moffett Field, Calif.
HUMAN BEHAVIOR AND PERFORMANCE
H. P. Klein 415-965-5094
(970-21-52)

The objective is to perform behavioral research on man as systems manager, scientist, and engineer/technician in space operations. The approach will be to: (1) conduct a systematic program of experimentation on major classes of performance likely to be effected by environmental variables, (e.g., information acquisition, processing, and utilization, observing, monitoring and tracking, higher level function (judgment, reasoning) and communication ability). (2) Develop methods for performance assessment which are sufficiently sensitive to detect subtle alterations in state of the organism. (3) Maintain capability in performance assessment in readiness to address specific questions of human performance as requirements arise. Conduct laboratory and field studies which explore new methods of maintaining or modifying individual and group behavior under conditions approximating space flight. Emphasis will be placed on studies of group function to provide information of value to promote optimally harmonious and efficient group function under conditions of long-term social isolation. The information sought will pertain specifically to selection methods and criteria, early identification of trends toward group disharmony, preventive techniques and corrective procedures.

W74-70783 **970-21-52**
Ames Research Center, Moffett Field, Calif.
BEHAVIORAL PHYSIOLOGY
H. P. Klein 415-965-5094

The objectives of this program are to establish in animals the brain mechanisms that regulate biologic rhythms and behavior and to apply this information via experiments in man to solving specific spaceflight related problems of behavior, performance and social interaction. Experiments in animals will study the central nervous system mechanisms controlling behavioral rhythms by restraint, drugs, alteration in food and water consumption, feeding time and food composition. Experiments in man will include studies of sleep-wake cycles and sleep deprivation in a time-free environment; correlating consumption of specific foods with serum amino acid rhythms and serotonin synthesis, sleep, alertness and body temperature; determining the ability of social interaction to maintain or reduce rhythm synchrony and performance and well-being in small groups of subjects in isolation; and quantitating the changes in sleep, performance and circadian synchrony of females in social deprivation.

W74-70784 **970-21-61**
Ames Research Center, Moffett Field, Calif.
REGULATORY BIOLOGY
H. P. Klein 415-965-5094

The objective is to establish the changes and mechanisms of functional adaptations of living systems when exposed to space flight environmental conditions. Functional variations and their controlling mechanisms will be studied in plant and animal systems at various levels of biologic organization. The research within the scope of this RTOP is related to the quantitation and delineation of the biochemical, anatomic and physiologic changes in organisms exposed to altered gravity. Representative biologic species, both plant and animal at different levels of biologic organization must be used, comparatively, to determine the influence of altered gravity on major biologic functions. Changes in gravity will be introduced by such means as acceleration (centrifuge), gravity compensation (clinostat), parabolic aircraft flights and body immobilization. Observations will be made of morphologic changes, of modified biochemical pathways and of changes in specific physiologic function consequent to changes in body functions likely to be manifest. A significant part of this effort is related to an elaboration of the regulatory factors in homestatic adaptation to and deconditioning from the metabolic stresses associated with a change in the gravity field. The mechanism(s) of graviperception are most important. Thus, a comprehensive, quantitative knowledge of the unique responses of a variety of living systems to space flight factors will afford valuable insights into the biologic aspects of manned space flight.

W74-70785 **970-21-62**
Ames Research Center, Moffett Field, Calif.
DEVELOPMENTAL AND GENETIC BIOLOGY
H. P. Klein 415-965-5094

The objective of this program is to determine the effects of space flight on genetic integrity, differentiation, growth, development, maturation and senescence of living systems. Research will be performed on the role of gravity, from high g to weightlessness, in the maintenance of cellular integrity, of cellular spatial relationships and in biochemical and biophysical reactions that control differentiation, growth, development and maturation of embryonic systems, both plant and animal. Of general importance is the determination of any subtle or gross effect of altered gravity on the organization of living matter during a complete life span in the space environment and its subsequent readaptation to earth's gravity. The quantitative comparative differentiation between gravity-dependent and gravity-independent systems will be evaluated critically. Also, experiments have been selected which can be developed into flight experiments to investigate the genetic effects of the space environment. Laboratory tests will be required to develop procedures and establish baseline genetic data. Improved techniques will be used to measure specific endpoints such as the use of electron microscopy in analyzing spindle malfunctions in plants. Methods of fixation of biological material in space for prolonged storage will be developed. A self-powered unit for fixation and preservation will be built. Radiation sources will be developed for in-flight use to detect synergism of radiation and weightlessnes in producing genetic damage. The effect of high Z cosmic ray particles will be determined.

W74-70786 **970-21-63**
Ames Research Center, Moffett Field, Calif.
RADIATION BIOLOGY
H. P. Klein 415-965-5094

A comprehensive study addressed to the space radiation problem for manned flights will be accomplished for the purpose of establishing realistic radiation exposure limits and developing protective and preventative procedures and techniques against hazards of space radiation. Emphasis will be placed on studies concerned with biological effects and relevant dosimetry of galactic cosmic ray particles, and combined effects of radiation and dynamic space flight factors. Both ground-based and space flight studies will be accomplished. Conduct intensive ground-based work utilizing a variety of biological materials and endpoints and existing or modified particle accelerators for irradiation to establish and understand the mode of action and the biologic

effectiveness of energetic, heavy-ions (HZE) at the molecular, cellular, and organism levels. Assess the acute and chronic effects of HZE particles on proliferating and non-dividing cells and the combined biologic effects of radiation, vibration, and compensated gravity. Establish the rate of production and energy spectra of high-LET recoil particles in tissue equivalent nuclear track detectors and develop capability to identify track, energy and charge of particle impacting biologic targets. Conduct balloon and/or space flight experiments to assess the biologic effectiveness of galactic cosmic rays in various biological materials, including brains and eyes of intact organisms, and the combined effects of radiation and dynamic space flight factors.

W74-70787 **970-22-21**
Ames Research Center, Moffett Field, Calif.
AIR RAVITALIZATION
H. P. Klein 415-965-5094
(970-22-30)

A program to conduct research and advanced technology development in air revitalization will be carried out by this center. The life support areas to be investigated are: advanced academic life support research; static-feed water electrolysis; nitrogen/hydrogen gas separation; electrochemical oxygen concentration; electrochemical CO2 concentration; trace contaminant control, s-lid electrolyte CO2 electrolysis; and membrane CO2 separation.

W74-70788 **970-22-23**
Ames Research Center, Moffett Field, Calif.
WATER AND WASTE MANAGEMENT
H. P. Klein 415-965-5094

Ames Research Center will conduct a program to perform research and advanced technology development in water and waste management. The areas to be investigated are: (1) urine pretreatment by stabilized urease enzyme; (2) membrane development for reverse osmosis applications; (3) membrane development for vapor diffusion water recovery (VDR) applications; solid waste incineration; and solid waste steam reforming.

W74-70789 **970-22-24**
Ames Research Center, Moffett Field, Calif.
FOOD TECHNOLOGY
H. P. Klein 415-965-5094

A program to conduct advanced food technology research will be carried out by this center. The areas to be investigated include: (1) chemical and enzymatic food synthesis of carbohydrate from CO2; and (2) growth of fresh food by hydroponic techniques.

W74-70790 **970-22-30**
Ames Research Center, Moffett Field, Calif.
CREW EQUIPMENT SYSTEMS
H. P. Klein 415-965-5094
(970-22-21)

Ames Research Center will conduct a program to perform research and advanced technology development in crew equipment systems. The areas to be investigated are: advanced space suit and glove development; advanced liquid cooled garment (and LCG thermal control); Regenerable Portable Life Support System (RPLSS) CO2 control; RPLSS - thermal control; and solid oxygen sources.

W74-70791 **970-23-20**
Ames Research Center, Moffett Field, Calif.
TELEOPERATOR MANIPULATOR AND END EFFECTOR TECHNOLOGY
H. P. Klein 415-965-5094

Ames Research Center will conduct a program to perform research and advanced technology development in remote manipulator systems for application to earth-orbital, lunar, and planetary, missions. The teleoperator manipulator and end-effector work will include: (1) improved unilateral and bilateral manipulator arms and dexterous end effectors; (2) advanced visual sensing and display systems to provide a 3-D view of the remote scene to a human operator; (3) predictor displays based on hybrid computer mapping, storing, and manipulating stereo pair information obtained from the stereo camera system; (4) study of man-machine integration problems associated with various levels of manual and automatic control; and (5) development and evaluation of advanced sensory aids and associated displays to provide relevant information of the remote scene to the human operator.

W74-70792 **970-23-30**
Ames Research Center, Moffett Field, Calif.
ADVANCED BIOINSTRUMENTATION
H. P. Klein 415-965-5094

The objective for work in this area is the development of bioinstrumentation techniques to enable the measurement of biological, physiological and psychological responses of man and/or selected animal species to actual or simulated space flight conditions, non-invasive, non-destructive testing procedures will be utilized for obtaining data wherever possible and feasible. The approaches will utilize ultrasound, microwaves, swallowable and implantable telemetry units, new ECG electrodes, sensors such as accelerometers to be placed on the body surface and radioactive scanning devices. Development of new laboratory techniques for processing blood and biological materials will also be pursued as well as new ways of preserving tissue samples. Lastly, new and improved microelectronic methods for measuring physiologic status during space flight will be developed. These methods will be applied to sensors and systems placed in or upon the body surface.

W74-70793 **970-23-40**
Ames Research Center, Moffett Field, Calif.
INTEGRATED BIOINSTRUMENTATION SYSTEMS
H. P. Klein 415-965-5094

An altered cardiovascular response has been regularly observed after manned space flight. Instrumentation techniques to observe and document these changes during flight are presently being developed and tested in ground-based experiments using bed-rest and in Skylab. It is the purpose of work in this area to integrate presently available bioinstrumentation measurement systems for measuring such cardiovascular function and identify those methods presently under ground-based investigation which have potential application for space flight use. Various methods for measuring cardiovascular function will be documented and assessed against methods being used for similar purposes at the bed-side or during cardiac catheterization. Non-invasive, non-destructive methods will be emphasized. Accuracy will be assessed against clinical standards. Efforts will be coordinated with JSC.

W74-70794 **970-24-01**
Ames Research Center, Moffett Field, Calif.
INTERDISCIPLINARY RESEARCH
H. P. Klein 415-965-5094

The objective is to provide support for preliminary investigation of various alternative advanced research and technology efforts which might ultimately become part of an approved programmed RTOP assigned to the Center. The Center Director of Life Science will be the sole authority for selecting those tasks which will become part of this RTOP. Task documentation outlining the efforts undertaken as part of this RTOP will be furnished for information purposes following assignment of the task by the Center Director of Life Sciences.

W74-70795 **970-24-04**
Ames Research Center, Moffett Field, Calif.
LIFE SCIENCES SORTIE LABORATORY CONFIGURATION/EXPERIMENT SIMULATION
H. P. Klein 415-965-5094
(970-24-03; 970-54-04; 970-64-03)

The major aim is to develop a three NASA center coordinated low-cost life sciences space research experiment program for the shuttle sortie. Candidate experimental protocols and research programs will be simulated and evaluated in a conceptual sortie lab to identify incompatibilities in protocols and between protocols and conceptual laboratory systems and to define effective means for reducing costs of required equipment and facilities without compromising the research capabilities. ARC (with the collaboration of scientists at JSC and outside of NASA) will develop, simulate and evaluate candidate experimental protocols and

research programs for carry-on and 7- and 30-day shuttle sortie payloads with emphasis on, but not limited to, bioscience (animals, invertebrates, plants and cells and tissue). In keeping with the concept of developing a low-cost, versatile research capability, breadboards of modularized off-the-shelf equipment will be used whenever practicable. The approach would provide for orderly growth and/or modifications as needed to meet research requirements. Succeeding simulation activities will update and expand research capability, operations and layout of equipment and facilities and test new concepts and additional research requirements which will impact the design and development of payload carriers. The conceptual sortie lab mock-up at ARC will be used to test the candidate protocols and research programs; the payload carrier simulator at MSFC will be used to conduct the protocol-conceptual laboratory systems integration testing in collaboration with MSFC.

W74-70796 **970-42-30**
Flight Research Center, Edwards, Calif.
CREW EQUIPMENT SYSTEMS
L. R. Carpenter 805-258-3311
(970-22-30; 970-52-30)

The objective is to provide applied technology development and simulated flight concept verification of flight crew personal equipment related to the shuttle spacecraft flight test vehicle program. The technical approach will include definition of crew equipments for the flight test vehicle and subsequent development and engineering simulation testing in support of the proposed operations.

W74-70797 **970-43-10**
Flight Research Center, Edwards, Calif.
SHUTTLE PILOT REQUIREMENTS
L. R. Carpenter 805-258-3311
(970-23-10; 970-53-10)

The objective of this RTOP is to establish information requirements necessary for approaches and landings using forward viewing television. These requirements, when established, shall define an advanced man/machine system allowing pilots to land aircraft using indirect viewing or to remotely pilot a flight vehicle into a landing. Outside visibility requirements for landings have been established by previous work accomplished under this RTOP, and it has been learned that only a small amount of forward viewing is necessary for making safe landings. However, when using electronic viewing it is anticipated that considerable larger viewing angles will be required to compensate for the decrement in viewing quality. Also, the decrement in electronic viewing may require additional information in the form of symbology displayed on the kinescope and/or external cues in the form of runway markings. These additional information requirements will be established by flight experiments designed to relate approach and landing performance to the pilots requirements for information. There---

W74-70798 **970-51-11**
Lyndon B. Johnson Space Center, Houston, Tex.
NEUROPHYSIOLOGY
W. H. Shumate 713-483-4731

The objective is to investigate and evaluate effects of the space environment upon the nervous system of man. This body system demands particular attention in that it constitutes the sensory, motor, and most significantly, the coordinating mechanisms for human performance and behavior. It is imperative that neurophysiological function is not impaired by exposure to any of the variables which are experienced during the course of a manned mission. The function of the nervous system is of major significance in any attempt to either evaluate or predict human capabilities and performance. It is to this end that work will be undertaken and directed. It is required that nervous system physiology be assessed both under conditions of ground based research and during space missions so that the information obtained can be utilized to insure appropriate safety and performance potential. Particular emphasis will be placed upon spatial orientation, motion sickness, levels of attention and alertness, since information concerning these has direct application to space flight operations and mission planning. Biochemical and bioelectric correlate of neurophysiological function and behavior will be studied. Weightlessness and its associated alteration of sensory input to the body, duration of sleep and its quality, work-rest cycles,---

W74-70799 **970-51-12**
Lyndon B. Johnson Space Center, Houston, Tex.
CARDIOVASCULAR PHYSIOLOGY
G. W. Hoffler 713-483-5555

The objective is to determine cardiovascular responses and/or adaptations to the various environmental factors associated with manned space flight. Particular attention will be given to the physiological responses to weightlessness and mission-like workloads. Emphasis will be placed on investigations pertaining to those factors which affect and the mechanisms which control the orthostatic response to gravitational fields following exposure to long-duration weightlessness. Ancillary effort will be directed towards other factors and balance, renal and endocrine control. Ground-based programs will include use of hypodynamic states; study of regulatory mechanisms and related physiologic systems and responses; development of measurement techniques, hardware, and data management and analysis capabilities; and conduct of pre-and postflight evaluations of space crews, and analyze data from inflight medical experiments.

W74-70800 **970-51-14**
Lyndon B. Johnson Space Center, Houston, Tex.
METABOLISM AND NUTRITION
John A. Rummel 713-483-5156
(970-52-20; 970-51-13)

Metabolic mechanisms which store and liberate heat and energy are the most basic processes in living systems. In supporting this scientific discipline we can divide it into three overlaping areas: (1) nutrition - the supply of adequate energy sources, (2) respiratory/metabolic - the transformation of energy sources to useful body processes and the resultant external work of the organism, and (3) thermal - the effect of the environment on the organism's ability to regulate the loss of the heat produced by metabolic processes. The specific objectives and approach in each of these areas is as follows (1) The nutrition - program has, as its end point, the development of criteria for optimum foods and packages. It approaches this goal through two major categories of effort: the derivation of nutritional and metabolic requirements and the design of foods and packages to meet those requirements. (2) The objective of the respiratory/metabolic program is to obtain an understanding of the homostatic mechanisms involved in the adaptation of man's energy transforming processes to the spaceflight environment. This will be accomplished by conducting basic research to evaluate the effect of abnormal and proposed environmental conditions on respiratory/metabolic function in order to determine human effects, tolerances, and protective/preventative requirements. (3) The physical effect of the spacecraft environment on thermoregulation has been included in a model of thermoregulation in man. Although no direct physiologic effect of the spacecraft environment is expected there may be interactions of the pulmonary and cardiovascular---

W74-70801 **970-51-15**
Lyndon B. Johnson Space Center, Houston, Tex.
HEMATOLOGY (IMMUNOLOGY)
S. L. Kimzey 713-483-4086
(970-51-16)

The overall objective of this program is to assess the physiological costs of manned space flight relative to the hematological and immunological systems. Advanced biochemical analytical techniques are being applied for: (1) detection and characterization of disease states prior to their clinical expression; (2) quantitative and qualitative analysis of cellular chemical constituents of the formed elements of the blood and muscle tissue; and (3) computerized cell identification and functional classification based upon pattern recognition and association routines. Studies are being conducted to perfect procedures for inflight acquisition and preparation of microsamples of blood for postflight physiochemical analysis.

W74-70802 **970-51-16**
Lyndon B. Johnson Space Center, Houston, Tex.
ENDOCRINOLOGY
C. S. Leach 713-483-5458

The overall program described herein is designed to further elucidate and define those physiological mechanisms which are operative in adaptation of the man to the space flight environment and in his readaptation to the earth environment following extended duration missions. In general, these investigations will be directed toward the identification of hormonal and neurohumeral agents which are active in the readaptive process and will be concerned with describing the relationship between these compounds and those organ systems which are affected by the space flight environment. Research emphasis will be placed on quantitation of endocrine compounds and their effects within the total system, as pertains principally to the regulation of fluid and electrolyte balance, acid-base equilibrium and metabolic physiology. The endocrine control of major system responses will include, but not be limited to, such areas as stress response, physiological cost and reserve, and nutritional effects. The effects of stress induced endocrine/metabolic processes will be examined in reference to the interrelationship of the hormonal system with metabolic process to identify those which are of importance in man's overall adaptation to environmental changes.

W74-70803 **970-51-17**
Lyndon B. Johnson Space Center, Houston, Tex.
COUNTERMEASURES
Paul C. Rambaut 713-483-5056

The objectives of investigations undertaken within the countermeasures area shall be to define, develop and evaluate preventive and/or remedial measures for mitigating the deleterious effects of prolonged weightlessness on crew and/or passenger personnel. These deleterious effects may appear during flight, but are apt to be more evident on return to force fields (l-g). Countermeasures may be physical, pharmacological, or dietary (nutritional) in character and shall relate to the known biomedical problem areas of space flight, viz., cardiovascular deconditioning (postflight orthostatism), bone demineralization, muscle mass loss, decreased exercise tolerance, deconditioning of ligamentous, tendinous or other supportive skeletal structures, and vestibular disfunction. Methods shall be largely empirical but not to the exclusion of defining mechanisms of action in more basic studies. Finally, countermeasures will be validated by appropriate stress testing, which may include centrifugation, zero-g flights, and other less elaborate verification techniques. Particular emphasis will be placed on maintaining the integrity of the cardiovascular and musculoskeletal systems, as well as of the general physical fittness of representative candidate crew and passenger populations. Bed rest will be the weightless analog utilized to simulate zero-g either inhouse or at contractor facilities. Such studies are now in progress at the USPHS Hospital, San Francisco in the mineral metabolism, fluid, electrolyte, and cardiovascular areas.

W74-70804 **970-51-25**
Lyndon B. Johnson Space Center, Houston, Tex.
CHEMISTRY AND MICROBIOLOGY
Vern Carter 713-483-5281

The basic objective is to identify and evaluate potential hazards to crews and passengers on OMSF missions. This includes programs to insure that the spacecraft has a compatible microbial ecology and that potential toxic contaminants are identified and evaluated. The current level of knowledge is not adequate to make satisfactory risk decisions for long-duration space flights, specifically, as related to our ability to provide man with a habitable non-toxic environment and our ability to control or modify the endogenous and exogenous infectious disease potential. The approach of reduction of this knowledge gap requires a three-phased coordinated course of study and action leading to the qualification of man and machine for extended-duration missions in space, as follows: (1) determine the nature and extent of problems; (2) derive effective methods of prevention and control; (3) provide microbiological toxicological support and monitoring systems for use inflight. All organized around this approach. This research approach involves: (1) studies utilizing in vitro techniques; (2) comparative studies utilizing animal hosts; (3) medical investigations utilizing man as the test subject.

W74-70805 **970-51-35**
Lyndon B. Johnson Space Center, Houston, Tex.
ENVIRONMENTAL FACTORS EFFECTS
E. L. Michel 713-483-3518

The objective of this work is to evaluate environmental factors such as spacecraft atmospheres and decompression profiles as to their physiological effects on man. Human testing, utilizing decompression profiles and atmospheres similar to those utilized in space will be done. The effects of interrupting a preoxygenation schedule for various lengths of time will be tested. Continued work in oxygen toxicity and the effects of subnormal and elevated pCO2 will also be done under this RTOP. Proposed space shuttle and ASTP flight profiles expose the crew and passengers to decompression profiles and suit and cabin atmospheres which need to be throughly studied as to their physiological effects. The objective is to assess the physiological effects of space suit and cabin atmosphere components and decompression profiles. The approach is to test human subjects in altitude chambers utilizing the environmental factors anticipated for space. Standard review and reporting requirements will be incorporated into the study.

W74-70806 **970-51-45**
Lyndon B. Johnson Space Center, Houston, Tex.
MEDICAL SUPPORT
Paul Buchanan 713-483-4021

The objective is to formulate programs, protocols and specifications for medical support of long duration manned space flight. The major parts of this plan involve the determinants for selection of space shuttle crews and passengers, the medical care of these and other future space travelers by computerized health maintenance programs and further investigations in preventive dentistry. Detailed physical and psychological examination protocols specifically for space travelers on long duration missions have yet to be developed. The many possible mission requirements of space shuttle make this now mandatory. The varied crew and passenger possibilities make this a more complex problem requiring increased effort in this area. The use of centrifuge here at JSC as well as the developed expertise in physiological assessment make the Center admirably suited for this program. An expansion of our MEDATA concept with a collating medical history - current findings - diagnostic computer program for eventual onboard use by space physicians is our second area of major thrust into future flight preparations. This can serve as an onboard data file, library and medical consultant and should have up and down link capability. The remote care spin-off possibilities are obvious. Inflight dental care remains an area in which prevention of need seems a most hopeful solution. A current and valuable program is to be continued with the next fiscal year. The assessment of the Skylab dental care activities is eagerly awaited.

W74-70807 **970-51-51**
Lyndon B. Johnson Space Center, Houston, Tex.
HUMAN BEHAVIOR AND PERFORMANCE
W. E. Fedderson 713-483-4731

The objective of research in this area is to optimize man's performance under conditions of long-term space flight. Areas being investigated are: (1) Skill retention for procedural, near-point and far-point control tasks over extended periods of time. (2) Personality and psychosocial assessment techniques validated and standardized for application to spacecraft crew command structure. To establish the basic principles for optimal structuring of small groups under conditions of isolation, confinement, and other stresses. To advance knowledge of human capabilities and limitations in behavior and performance relevant to roles man must fulfill in space. The approach will be to (1) identify and select far-point control task requirements, develop candidate skill retention methods, train subjects to conduct tests, and select optimum skill retention methods and specify prototype design requirements: and (2) establish a baseline battery of standardized psychosocial assessment measures for application to crew command structures. Major initial emphasis will be placed on

the development of criteria for the selection of individuals for membership in groups which are assigned specific mission tasks. Methods for continuous assessment of performance and group interaction over long periods of time will be defined and validated. Such methods should be sufficiently sensitive to detect alteration in the effectiveness of individual and group functioning under adverse conditions such as rhythm desynchronization, sleep deprivation, and situational stress. Research will be devoted to the programming of environmental events and procedures for the prevention and correction of undesirable behavior resulting from social and ---

W74-70808 **970-51-62**
Lyndon B. Johnson Space Center, Houston, Tex.
DEVELOPMENTAL BIOLOGY AND GENETICS
J. A. Mason 713-483-2228

Studies are underway at the Johnson Space Center to determine the effects of the space environment on differentiation, growth, development, maturation, and senescence of living systems. The primary objectives of this work are to evaluate the dependency of plant growth upon specific environmental factors, to assess the effects of reduced gravitational and geomagnetic forces on growth and development of plants and animals, and to devise and evaluate experimental techniques for possible adaptation to flight experiments. Specific attention is being given to measurements of aromatic amino acid metabolism. In all studies, the overall approach is to utilize biological systems in which the compensation to environmental stress has been exaggerated by an obvious modification in cellular behavior. Emphasis is being placed on measuring cellular products and enzymes of aromatic amino acids in species exposed to altered gravity, reduced geomagnetic forces, modified gaseous environments, and modified nutritional conditions. Whenever possible, tissue cultures are being utilized to permit measurements to be made at the cellular level. The approach to all tasks is to cooperate extensively with Universities in a manner that utilizes unique resources of the Johnson Space Center.

W74-70809 **970-51-63**
Lyndon B. Johnson Space Center, Houston, Tex.
RADIATION BIOLOGY
R. A. Hoffman 713-483-3419

This research program is designed to investigate and define the biological hazards of the space radiation environment to manned space missions. Also included for study is the consideration of preventive techniques or measures that space travelers may take when faced with unavoidable exposure to a relatively high radiation dose (e.g., solar flare). Although experimental animals comprise the major source information, human response data resulting from radiation therapy and accidental exposures are included. Investigating the response to and mechanism of action of high energy high Z (HZE) cosmic particles is emphasized. Also emphasized is further definition of effects resulting from low dose, low dose rate, and fractionated dose exposures. Determining whether significant physiological changes have occurred even though gross responses may not be evident is of major importance throughout these studies. Considerably more data is needed in this area to more accurately specify safe and reasonable radiation safety criteria for manned space programs.

W74-70810 **970-52-10**
Lyndon B. Johnson Space Center, Houston, Tex.
LIFE SUPPORT SYSTEMS PROGRAM
Frank H. Samonski, Jr. 713-483-2171

The objective of the Lift Support Systems Program is to focus analysis, fabrication and testing efforts toward solving problems associated with the integration life support system hardware. The basic approach involves the use of analytical studies to guide the selection of optimum subsystem combinations, the implementation of the results of these studies into hardware programs and the confirmation of the validity of these efforts through a coordinated ground test program. Specific programs involve the development of system level computer programs for analysis of shuttle and potential shuttle payload environmental control and life support systems, the continuation of the development of a representative shuttle environmental control system, and the fabrication of selected SSP EC/LSS subsystems.

W74-70811 **970-52-21**
Lyndon B. Johnson Space Center, Houston, Tex.
AIR REVITALIZATION AND CONTAMINANT CONTROL
Frank H. Samonski, Jr. 713-483-2171
(970-22-21; 970-62-40)

The objectives of this RTOP are to provide advanced life support technology for components and subsystems for air revitalization, atmosphere storage and generation and control techniques for carbon dioxide, humidity and trace contaminants of manned spacecraft cabins. The general approach is to advance the subsystem technology through to the design and verification of reliable hardware for shuttle and near term space missions. Performance data on subsystems and components will provide a basis for selection of critical subsystems to make them adaptable to flight type hardware.

W74-70812 **970-52-22**
Lyndon B. Johnson Space Center, Houston, Tex.
ATMOSPHERIC PRESSURE, COMPOSITION AND THERMAL CONTROL
Frank H. Samonski, Jr. 713-483-2171
(970-62-40)

The objectives of this RTOP are to provide advanced life support technology for components and subsystems for cabin atmospheric control of such parameters as pressure, composition and temperature as well as required environmental control subsystem sensors. The general approach is to advance the subsystem technology through to design and verification of reliable hardware for shuttle and near term space missions. Performance data on subsystems and components will provide a basis for selection of critical subsystems to make them adaptable to flight type hardware.

W74-70813 **970-52-23**
Lyndon B. Johnson Space Center, Houston, Tex.
WATER AND WASTE MANAGEMENT
Frank H. Samonski, Jr. 713-483-2171
(970-22-23; 970-62-40)

The objectives of this RTOP are to provide advanced life support technology for components and subsystems for water management, including water purification and the management and control of manned spacecraft wastes. The general approach is to advance the subsystem technology through to the design and verification of reliable hardware for shuttle and near term space missions. Performance data on subsystems and components will provide a basis for selection of critical subsystems to make them adaptable to flight type hardware.

W74-70814 **970-52-24**
Lyndon B. Johnson Space Center, Houston, Tex.
FOOD TECHNOLOGY
N. D. Heidelbaugh 713-483-5066
(970-22-24)

The objective is to develop food systems having maximum palatability and nutrition with minimum in-flight food preparation time, and minimum cost, volume, weight and power requirements. The approach will be to exploit food technology, food sciences and food engineering to support research and development of food systems. Emphasis will be on food systems, preservation techniques, packaging and storage. Particular attention will be given to those techniques which are judged to be most likely to aid in achievement of space food systems engineering design goals. Emphasis will be placed on specialized technical areas neglected by the commercial food industry. These efforts will be complemented by tasks to select and adapt commercially developed food technology and food engineering techniques. Priorities will be given to development of overall concepts for advanced food systems by tradeoff analyses, optimization of space food preservation techniques, optimization of packaging, and development of efficient in-flight food storage, preparation, and delivery systems, and subsystems hardware. Food will be developed to meet mission needs prior to development of food system hardware design specifications. System compo-

nents will be adapted to mission requirements rather than compromised to fit commercially available foods.

W74-70815 **970-52-30**
Lyndon B. Johnson Space Center, Houston, Tex.
CREW EQUIPMENT SYSTEMS
C. C. Lutz 713-483-5234
(970-22-30; 970-42-30)

The objectives are to: (1) initiate component technology design, development, fabrication, and testing of a shuttle related EVA life support system; (2) continue the design, development, fabrication, and testing of prototype advanced IV and EVA technology suits for application in the space shuttle program; and (3) continue development of an elastomeric polymer material that will be flame resistant in an O2 enriched environment (70/30 ration of N2 and O2). Material will also be capable of molding and extruding while maintaining resiliency and elasticity. EVA life support system components to be developed include those that exhibited design deficiencies in prior life support system application or require specific modifications as a result of unique shuttle related requirements. The continued design, development, fabrication, and testing of the prototype advanced IV and EVA suits as well as the development of the flame resistant elastomeric polymer material will be conducted through an increase in scope and follow-on efforts to existing contracts.

W74-70816 **970-53-10**
Lyndon B. Johnson Space Center, Houston, Tex.
SHUTTLE MAN-MACHINE INTEGRATION TECHNOLOGY
T. U. McElmurry 713-483-6416
(908-42-42)

The goal of this RTOP is to develop simulator requirements specifications, maintenance and stowage process and product specifications and update the EVA Guidelines and Design Criteria Document. The specifications will be used for development of operational techniques and resources requirements associated with crew integration, training and operations while the EVA document will aid mission planners and spacecraft designers on future manned space programs. Task 21 - Shuttle Mission Simulator Definition - Development and documentation of requirements specifications for a shuttle mission simulator. Task 22 - Shuttle Simulator Visual System Definition - Development and documentation of requirements specifications for a shuttle crew training visual simulation system. Task 31 - In-Flight Maintenance and Stowage Operations - Development of specifications for controlling and managing crew interface requirements for in-flight maintenance and stowage functions. Phase III activities will result in the generation of specifications that describe the in-flight maintenance management process and task analysis. Task 32 - Application of EVA Guidelines and Design Criteria - Development and documentation of EVA requirements for use by mission planners and designers. Expansion of the EVA Guidelines Document in the areas of: (1) EVA equipment design/selection considerations, (2) requirements for a general purpose EVA work station and (3) baseline EVA system.

W74-70817 **970-53-20**
Lyndon B. Johnson Space Center, Houston, Tex.
ATTACHED MANIPULATOR SYSTEM
Richard B. Davidson 713-483-4966

Task 11 involves analysis, evaluation, fabrication and simulation of a manipulator system for deploying and retrieving shuttle payloads and inspecting and servicing shuttle payloads and satellites. The objectives of this effort will be to fabricate a technology manipulator system defined under FY73 RTOP 970-53-20-11 and to conduct in-house simulation program to investigate and evaluate large mass handling with a long flexible manipulator and various manipulator control techniques and concepts. Task 12 involves modification of the NASA-JSC CAM 1400 Manipulator Simulator will involve equipment design, development, and fabrication at the contractor's site; and equipment modification, refurbishment, installation, and verification at JSC. The CAM 1400 Manipulator Simulator is used for terrestrial applications only and is not flight hardware.

W74-70818 **970-53-30**
Lyndon B. Johnson Space Center, Houston, Tex.
ADVANCED BIOINSTRUMENTATION
S. L. Pool 713-483-4211

The advanced bioinstrumentation program has resulted in the production of items of biomedical hardware for flight application. For example, several items originally included in the advanced bioinstrumentation program are now scheduled to fly on Skylab. Included in this RTOP are several programs such as the Microbial Load Monitor and the GO Analyzer which hold great promise for use on future manned space missions. The objective of the advanced bioinstrumentation program being conducted at JSC is to develop and test space-applicable bioinstrumentation. The advanced bioinstrumentation program is a multi-disciplinary effort; included are efforts in microbiology, cardiology, and engineering. The programs in this area usually start as study efforts, although several have now reached the ground-based hardware production phase.

W74-70819 **970-53-40**
Lyndon B. Johnson Space Center, Houston, Tex.
INTEGRATED BIOINSTRUMENTATION SYSTEMS
N. Belasco 713-483-4211
(970-53-30)

The objective is to formulate and verify the engineering and medical procedures for health care delivery to crewmen and passengers during spaceflight. This will be accomplished by evaluating advanced bioinstrumentation technology (hardware and protocols) in remote health care ground based tests and developing a biotelemetry system which permits astronauts freedom from hardline encumbrances. This effort will be directed toward continuing the development of remote health care systems utilizing a ground based IMBLMS concept. The IMBLMS test bed will accommodate the integration and evaluation of advanced bioinstrumentation developments and technology. Resulting procedures and requirements will be applied to the definition and development of manned spaceflight mission payloads, including instrumentation and procedures to support inflight medical research and to provide an inflight clinical capability for shuttle, space labs, and beyond. Major subtasks include: 1. Development of remote health care techniques (IMBLMS) (the definition and design, assembly and test, installation and operation of a ground based remote health care delivery system using the IMBLMS concept). The system test bed shall accommodate incorporation of advanced bioinstrumentation developments wherever practicable to improve the efficiency or enhance the total capability of the system; provide for a critical evaluation of advanced bioinstrumentation in a clinical setting, and for feedback of results, including requirements for modification and new concepts. Additional goals shall include the evaluation of equipment, procedures, and management of health care system, recommending appropriate modifications, and factoring the results into definition and planning studies for shuttle flights and beyond.---

W74-70820 **970-53-50**
Lyndon B. Johnson Space Center, Houston, Tex.
MAN-MACHINE SYSTEM DESIGN
Allen J. Louviere 713-483-4966

The objective of this effort is to develop and determine the suitability of engineering verification test articles for both the zero-g worksite restraint and a lightweight stowable launch/reentry restraint. The effort shall include design, development, fabrication, test, simulations and delivery of an engineering verification test article for each restraint concept defined.

W74-70821 **970-54-01**
Lyndon B. Johnson Space Center, Houston, Tex.
INTERDISCIPLINARY RESEARCH
Richard S. Johnston 713-483-3503

The Life Sciences Directorate at Johnson Space Center is responsible for the development of a comprehensive biomedical research program in support of manned space flight. This broad, multidisciplined mandate to acquire new knowledge is directed toward the acquisition of definitive data regarding the effects of the space environment on life systems in order to define the

critical physiological and psychological variables which must be integrated into the overall considerations of spacecraft designers and mission planners. The objective of the interdisciplinary research RTOP is to provide flexibility in the accomplishment of this goal. The responsibility for planning, implementing and continually evaluating the life sciences programs at Johnson includes the need to provide support for preliminary investigation of various alternative advanced research and technology efforts which might ultimately become part of an approved programmed RTOP assigned to the Center. An aggressive and responsive attention to alternative advanced programs requires that the Center Director for Life Sciences have some autonomous discretion in the pursuit of tentative investigations. The Center Director of Life Sciences will be the sole authority for selecting those tasks which will become part of this RTOP. Task documentation outlining the efforts undertaken will be furnished for information purposes to NASA headquarters.

W74-70822 **970-62-40**
Marshall Space Flight Center, Huntsville, Ala.
CVT EC/LSS SUPPORT PROGRAM
G. D. Hopson 205-453-3830

The objective of this RTOP is to provide the technology required for the flight test of various regenerative life support systems. Hardware will be designed, fabricated, ground tested and aircraft flight tested as applicable with a view of preparing for orbital flight tests. Program cost estimating methods and improved equipment life will also be investigated. Individual tasks are: (1) zero G life support processes, (2) rite water waste management system, (3) Bosch CO2 reduction, (4) cost prediction studies, and (5) long life components.

W74-70823 **970-63-10**
Marshall Space Flight Center, Huntsville, Ala.
REQUIREMENTS FOR PAYLOAD WORKSTATION DESIGN
J. R. Thompson 205-453-3739

The objectives are to develop through engineering analysis and ground based simulation, requirements, and criteria for the design of space shuttle payload man-machine interfaces. The three major portions of the RTOP are: (1) establishing man-machine design criteria for multidiscipline payload workstation accommodations, (2) define and experimentally test techniques for handling typical laboratory fluids and supporting equipment in zero-gravity, and (3) define the roles of man in spacecraft experimental laboratories. The general approach to be taken involves (1) an in-depth understanding of the design criteria need of sortie lab program in areas relating to the man-machine interface, (2) followed by data collection and analysis of past experience during spacecraft laboratory development and flight, (3) definition of man-machine design criteria for experimenter use during sortie lab system and experiment development, and (4) ground test verification of the design criteria, where appropriate. In the future, NASA will select and configure orbiting research facilities which accommodate a wide range of disciplines and technical interests, for both short and long term missions, in order to be compatible with the concept of the shuttle program and its projected payloads. The need to meet and coordinate the operational requirements for a select group of astronauts will broaden to encompass a wide variety of experimenters and scientific disciplines. The many design aspects of spacecraft laboratory operation and integration must be channeled to provide a productive and supportive environment for a large population of scientific investigators, including representatives of foreign countries.

W74-70824 **970-63-20**
Marshall Space Flight Center, Huntsville, Ala.
TELEOPERATOR CONTROL AND MANIPULATION
W. G. Thornton 205-453-5530

This RTOP proposes to further develop the technology applicable to earth orbiting teleoperator such that design criteria and requirements are available in the 1976 time frame and for subsequent applications. The principle technical areas of concern are: manipulative devices including the end effectors and their control; visual and other sensors; remote control of the mobility unit; man-machine interface and system integration; applications analysis and interfaces with shuttle, tug and payloads. The objectives are (1) to define experimental and prototype free flying teleoperator systems and operations for applications in shuttle, tug, and earth orbiting payload applications; and (2) to establish component and integrated system technology, design criteria and requirements for free flying teleoperators in the areas of manipulative devices and end effectors, sensory systems, mobility unit control, and the control and display station. Using prior system studies as a baseline and utilizing current design efforts in shuttle, tug, payloads, etc., system definition investigations will be conducted for specific applications of free flying teleoperators. Feasibility studies and design investigations will be undertaken on remote manipulators, and effectors, visual systems, displays, and remote control; and man-machine integration methodology for remote, free flying teleoperator systems will be evaluated.

W74-70825 **970-64-03**
Marshall Space Flight Center, Huntsville, Ala.
LIFE SCIENCES INTEGRATION STUDY (NEW TITLE)
J. D. Hilchey 205-453-3431
(970-24-04; 970-54-04)

The objective is to develop life sciences payload integration data and engineering and administrative planning tools for NASA use in establishing programs for integration of life sciences payloads into manned space systems and in guiding manned space flight planners in development and integration of life sciences laboratories beginning with a phase B new start in FY-76. During 1970-72, baseline manned life sciences laboratories were defined, and preliminary conceptual approaches were prepared. In 1972-73 refined subsystem definitions were developed along with updated conceptual designs, integration analyses, and initial estimates of costs, schedules, and SRT requirements for sortie-type laboratories. First conceptual approaches were also prepared for life sciences carry-on laboratories. FY-73 funds will further develop carry-on lab concepts and refine laboratory research and support equipment costing estimates. An expansion of the FY-73 costing work with FY-74 funds will be required to define costs, facilities, and manpower for laboratory integration, project management, flight operations, and ground support. In-house studies of carry-on lab interfaces with carrier vehicles will be accomplished. A PAD for development of life sciences labs will be prepared in FY-74 to permit initiation of Phase B activities in FY-76 and completion of laboratory physical integration and test in CY-79. Competitive final integration concept design studies will be implemented in FY-75 to establish the competitive contractor base, and the technical and administrative data base required to initiate Phase B efforts in early FY-76.

W74-70826 **970-64-04**
Marshall Space Flight Center, Huntsville, Ala.
LIFE SCIENCES INTEGRATION STUDIES RELATED TO CONCEPT VERIFICATION TESTING (CVT)
C. B. May 205-453-3431

The objective is to develop life sciences payload integration data for NASA use in the development of life sciences laboratories that can be flown aboard the shuttle program during the early 1980's. Life sciences laboratories of the dedicated and carry-on category have been defined and are presently being studied by the life sciences payload integration study. This effort will utilize the outputs from the Integration Study in order to test hardware and show feasibility of the life sciences laboratory concept. The FY-74 funds will be used to: (1) fabricate an integration fixture to be used at JSC for initial development of life sciences biomedical hardware for CVT, (2) to obtain commercial off-the-shelf hardware for the purposes of rating it relative to its capability to perform under manned space environmental conditions.

W74-70827 **970-71-61**
Wallops Station, Wallops Island, Va.
REGULATORY BIOLOGY
E. M. Holton 703-824-3411

The objective is to understand the response of living systems to gravitational changes by delineating the biochemical and physiological mechanisms associated with metabolic regulation

during simulated and actual space flight. The metabolic response to hypergravity and to simulated weightlessness is being explored. Depressed metabolism is being used for potential simulation of weightlessness, for antagonism to radiation-induced damage, and for mechanisms of delayed metabolism which allow injury repair processes to avoid untoward effects. Differences in function between rapidly metabolizing systems and those more mature and metabolically stable are being established. Regulatory mechanisms are being investigated. A consortium of investigators has been established and a space flight experiment is being defined.

W74-70828 **970-83-20**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
REMOTELY MANNED SYSTEMS: DISPLAYS AND SUPERVISORY CONTROL
Ewald Heer 213-354-3060
(115-04-20; 970-23-20; 970-63-20; 112-30-14)

The general objective of this program is to develop needed information about RMS and teleoperator/robots that augment and extend man's capabilities into space so that missions requiring the use of such systems can be planned and implemented with the required reliability, performance and economy. Specific objectives of the work of this RTOP are to identify and establish RMS and teleoperator/robot system and subsystem requirements, designs and breadboard to determine the machine's and man's complementary roles in the operation of RMS and teleoperator/robots, particularly with time delay requirements. The objectives of this program will be approached through technical studies identifying the scientific and operational mission requirements and by developing the resultant necessary RMS and teleoperator/robot functions, by man and machine in the control center, and by the remote system (robot) at the remote site. From the implied capability requirements for man and machine, the necessary technology developments for teleoperator/robot systems and subsystems will be derived. Required developments will be defined and implemented, analytically and/or experimentally using simulation techniques, breadboard set-ups, or prototype equipment. These studies will give insight into the functions to be performed by man or machine or both for remote explorations and operations. Function allocations will be made between man and machine for various communication time delay requirements, so that optimum system performance can be achieved, and critical technology development requirements can be identified. New concepts of teleoperator/robot systems and subsystems will be developed when appropriate and related feasibility studies will be conducted. Man-machine system performance evaluations will be conducted and performance criteria will be established. This work will be coordinated with related work at JPL, ARC, JSC, and MSFC.

Payloads

W74-70829 **975-70-52**
Langley Research Center, Langley Station, Va.
STUDY OF AN ORBITING ADVANCED TECHNOLOGY LABORATORY (SHUTTLE COMPATIBLE)
Eugene S. Love 703-827-2893

The use of space by competent researchers is a national asset that can quicken the pace of technological advancements beneficial to domestic needs. The objective of this study is to define a shuttle compatible Advanced Technology Laboratory (ATL) particularly suited to Langley Research Center's technical expertise and research requirements. This laboratory will provide LRC with the capability of implementing a spaceborne research program that is truly accessible to the ground-based researchers. The study effort will include the further definition of those areas of research needing shuttle sortie capability. Design concepts for candidate ATL experiments will be developed. An analysis will be made of the experiment integration, checkout, orbital operation, and data recovery required of the ATL. Definition studies will be made which will develop preliminary experiment laboratory equipment designs, schedules, and resource information for phased follow-on design, development, and operations activity.

W74-70830 **975-72-51**
Langley Research Center, Langley Station, Va.
DEFINITION OF LONG DURATION EXPOSURE FACILITY FOR SHUTTLE LAUNCH AND RECOVERY
Eugene S. Love 703-827-2893

A simple, inexpensive long duration exposure facility and a set of compatible noncritical experiments, which will be capable of obtaining valuable scientific and technological data on the near-earth space environment and the effects of this environment on spacecraft materials, systems, simple life forms, etc., will be defined: The definition will be such that shuttle induced environments for payloads can also be investigated with experiments on the facility. A ground rule for facility definition will also be that the facility can be placed in orbit and later returned to earth on early shuttle development missions and in no way interfere with the primary purpose of these missions; namely, the development of the shuttle. The investigations and definition of experiments for the facility will be performed by LRC with the aid of other NASA Centers as well as contracted activities in industry, universities, etc. The investigations and definition of the facility configuration and facility systems will be under the overall direction of LRC.

W74-70831 **975-73-48**
Langley Research Center, Langley Station, Va.
DEFINITION OF EXPERIMENTS FOR A PHYSICS AND CHEMISTRY LABORATORY IN SPACE
Eugene S. Love 703-827-2893

NASA programs such as space shuttle and space station offer unparalleled opportunities for scientific investigations in space covering a wide range of technical disciplines. Two important and related disciplines are physics and chemistry. NASA is planning a space laboratory to support a wide range of original physics and chemistry experiments which make use of the unique environmental conditions in space. It is envisioned that this laboratory will be available to universities and research laboratories, both in the U.S. and abroad, to conduct experiments with a minimum of expense and lead time, and thus allow new opportunities to experimenters who might otherwise be unable to participate in space experiments. Previous studies have developed a catalog of experiments considered representative of the types of experiments which will be performed in space in the next decade. Follow-on studies have used the experiment requirements as input to space shuttle, space station, research applications module (RAM), and other studies to identify interface and support requirements. The study proposed herein will extend work done in the past by (1) defining a small number of specific experiments to be conducted in a physics and chemistry laboratory in space, (2) identifying potential principal investigators for each experiment, and (3) conducting experiment definition studies for the more promising experiments.

RTOP CHANGE LISTING

The following RTOPs previously announced in FY 1973 have been changed, terminated or completed as indicated below.

RTOPs CHANGED

RTOP NUMBER	ACCESSION NUMBER	NEW RTOP NUMBER
501-01-03	W73-70002	502-01-03
501-06-11	W73-70109	743-65-31
	W73-70110	
501-01-10	W73-70004	502-01-08
501-21-33	W73-70006	502-21-33
501-24-19	W73-70079	743-34-11
501-24-20	W73-70080	743-34-11
	W73-70081	743-34-11
501-31-71	W73-70015	743-31-01
501-32-01	W73-70029	743-32-01
501-32-02	W73-70030	743-32-11
501-32-03	W73-70031	743-32-12
501-32-04	W73-70032	743-32-23
501-32-05	W73-70033	743-32-21
501-32-06	W73-70034	743-32-22
501-32-07	W73-70035	743-36-04
502-11-11	W73-70372	759-11-21
502-33-83	W73-70357	503-33-13
502-33-86	W73-70360	502-33-53
502-33-92	W73-70364	502-33-11
502-33-93	W73-70365	502-33-31
502-33-94	W73-70366	502-33-54
503-10-01	W73-70424	502-10-01
	W73-70422	
	W73-70413	
503-10-02	W73-70426	502-10-02
	W73-70425	
	W73-70427	
503-10-03	W73-70432	502-10-02
	W73-70430	
	W73-70428	
	W73-70431	
	W73-70429	
503-10-04	W73-70433	502-10-04
	W73-70434	
756-47-01	W73-70385	756-48-01
757-51-09	W73-70386	502-24-08
760-65-01	W73-70146	743-65-11
760-65-03	W73-70147	743-65-12
760-65-04	W73-70149	743-65-21
	W73-70148	
760-65-05	W73-70150	743-36-22
760-65-06	W73-70151	743-36-01
760-65-07	W73-70152	743-36-11
760-65-08	W73-70153	743-36-12
760-65-09	W73-70154	743-65-01
768-81-03	W73-70227	768-83-03
768-81-04	W73-70228	768-83-04
768-81-05	W73-70229	768-83-05
768-81-08	W73-70230	768-83-02
790-90-04	W73-70374	790-93-09
790-91-44	W73-70379	790-93-44
790-91-02	W73-70376	790-93-08
790-91-03	W73-70185	790-93-06
791-91-09	W73-70188	791-93-09
502-28-34	W73-70369	502-19-34
790-91-41	W73-70377	790-93-41
790-91-42	W73-70378	790-93-42
790-91-45	W73-70380	790-93-45
502-28-31	W73-70370	502-19-31
791-92-04	W73-70192	791-93-12
791-94-60	W73-70201	791-93-60
791-94-61	W73-70202	791-93-61
503-35-03	W73-70409	502-19-31

RTOPs TERMINATED

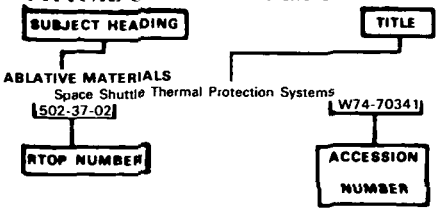
RTOP NUMBER	ACCESSION NUMBER
501-01-02	W73-70001
501-21-26	W73-70011
501-22-01	W73-70017
501-22-05	W73-70019
501-22-07	W73-70021
501-32-60	W73-70036
501-06-04	W73-70099
501-38-17	W73-70168
	W73-70169
501-38-16	W73-70182
502-01-02	W73-70233
	W73-70234
502-21-27	W73-70247
502-21-28	W73-70249
	W73-70250
502-21-29	W73-70251
502-21-30	W73-70253
	W73-70255
502-21-32	W73-70256
502-31-52	W73-70261
502-31-53	W73-70262
502-22-01	W73-70263
502-22-04	W73-70266
502-22-06	W73-70268
502-25-59	W73-70306
502-25-72	W73-70308
502-35-60	W73-70311
502-03-31	W73-70327
502-23-21	W73-70348
502-33-88	W73-70362
502-19-20	W73-70371
755-43-11	W73-70383
758-57-04	W73-70390
758-57-11	W73-70391
760-61-01	W73-70126
760-63-01	W73-70134
760-64-02	W73-70143
791-90-03	W73-70184
791-93-02	W73-70194
501-38-12	W73-70172
501-22-03	W73-70028
501-01-03	W73-70002
501-01-10	W73-70004
501-21-33	W73-70012
501-31-71	W73-70015
502-22-02	W73-70264
502-32-03	W73-70272
502-32-04	W73-70273
502-22-03	W73-70265
502-31-50	W73-70259
501-23-23	W73-70042
501-23-60	W73-70044
502-33-83	W73-70357
502-33-85	W73-70359
502-33-86	W73-70360
502-33-91	W73-70363
755-43-11	W73-70383
501-06-07	W73-70111
501-06-09	W73-70114
501-21-26	W73-70011
501-24-17	W73-70092
501-26-07	W73-70122
501-26-09	W73-70124
501-38-12	W73-70172
502-33-84	W73-70358
502-33-88	W73-70362
502-35-64	W73-70313
757-53-30	W73-70387
758-56-47	W73-70389

RTOPs COMPLETED

RTOP NUMBER	ACCESSION NUMBER
501-23-22	W73-70041
501-38-18	W73-70173
502-23-45	W73-70337
502-23-13	W73-70344
502-23-16	W73-70347
502-33-81	W73-70355
502-33-82	W73-70356
502-33-87	W73-70361
502-28-33	W73-70368
765-68-01	W73-70206
791-93-01	W73-70193
502-33-84	W73-70358

RTOP Summary

TYPICAL SUBJECT INDEX LISTING



A title is used to provide a more exact description of the subject matter. The RTOP accession number is used to locate the bibliographic citations and technical summaries in the Summary Section.

A

B

C

D

E

F

G

H

I

J

K

L

M

N

O

P

Q

R

Page Intentionally Left Blank

T

U

V

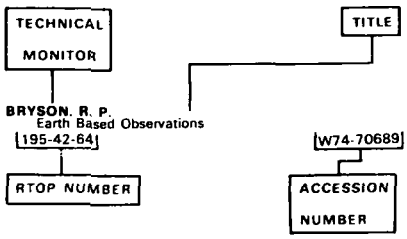
W

X

Z

Page Intentionally Left Blank

TYPICAL TECHNICAL MONITOR INDEX LISTING



The RTOP accession number is used to locate the bibliographic citations and technical summaries in the Summary Section.

A

B

C

D

E

F

G

H

J

K

L

M

N

O

P

R

S

T

U

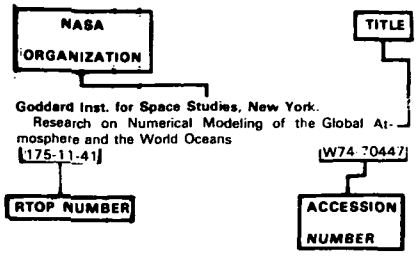
V

W

Y

RTOP Summary

TYPICAL RESPONSIBLE NASA ORGANIZATION INDEX LISTING



Listings in this index are arranged alphabetically by Responsible NASA Organization. The title of the RTOP provides the user with a brief description of the subject matter. The accession number denotes the number by which the citation and the technical summary can be located within the Summary Section. The titles are arranged under each Responsible NASA Organization in ascending accession number order.

A

Ames Research Center, Moffett Field, Calif.

Polymers
501-21-22 W74-70006

Fatigue, Fracture, and Life Prediction
501-21-21 W74-70009

Fire Retardant Materials for Military Programs
501-31-90 W74-70011

Loads, Aeroelasticity, and Structural Dynamics
501-22-05 W74-70014

Application of Control and Guidance Theory to the Automatic and Manual Control of Future STOL and VTOL *Aircraft*
501-03-11 W74-70025

Pilot Training Research
504-09-05 W74-70030

Acceptance of Aircraft Operations - Technology Assessment
504-29-01 W74-70032

Acceptance of Aircraft Operations - Technology Assessment
504-29-01 W74-70033

Flight Management Systems
504-29-02 W74-70037

Simulation Technology for Aeronautics - Piloting Cues
504-29-03 W74-70039

Simulation Technology for Aeronautics - Systems
504-39-01 W74-70041

Basic Noise Research
501-04-01 W74-70045

Production and Dispersion of Pollution from Jet *Aircraft*
501-04-02 W74-70049

Basic Propulsion Research
501-04-03 W74-70051

Inlet Technology
501-24-05 W74-70059

VTOL Technology
501-24-11 W74-70074

Computational Aerodynamics
501-06-01 W74-70076

Development of Computational Aeronautical Codes for Illiac
501-06-02 W74-70078

Physical Modeling and Verification of Illiac Computer Codes
501-06-03 W74-70079

Airfoil and Configuration Aerodynamics
501-06-05 W74-70083

Nonsteady Aerodynamics
501-06-06 W74-70084

Turbulent Boundary Layers
501-06-08 W74-70086

Flow Measurement Techniques
501-06-10 W74-70088

Wake Vortex Minimization
501-06-12 W74-70089

Airframe Aerodynamic Noise
501-06-13 W74-70093

Tunnel and Scale Effects on Transonic Flow
501-06-09 W74-70097

Handling Qualities - Turbulence/Flexibility Effects
501-26-02 W74-70099

Vehicle Dynamics - Stall/Spin/High Alpha Characteristics
501-26-04 W74-70101

General Aviation - Technology
760-60-01 W74-70104

Powered-Lift (STOL/RTOL) Aerodynamic Performance
760-61-02 W74-70108

STOL/RTOL Flight Dynamics
760-61-03 W74-70109

VTOL Aerodynamic Performance
760-62-01 W74-70110

VTOL Flight Dynamics
760-62-02 W74-70113

Handling Qualities Requirements for Ship-Based VTOL
760-62-03 W74-70114

Simulation Math Models of Advanced Transports
760-62-04 W74-70115

Helicopter Aerodynamic Performance Dynamics and Noise
760-63-02 W74-70116

Tilt Rotor Aircraft Aerodynamic Performance
760-63-03 W74-70118

Rotorcraft Flight Dynamics - Tilt Rotor Aircraft
760-63-04 W74-70120

Subsonic/Sonic Aircraft Aerodynamic Performance
760-64-01 W74-70124

Civil Aircraft Development Testing
760-64-03 W74-70125

Civil A/C Development Testing (Other Government Orgs. Except DOD)
760-64-04 W74-70126

Military Aircraft - Aircraft Aerodynamics
760-67-01 W74-70132

DOD Assistance
760-17-01 W74-70137

Tire Traction, Braking
501-38-12 W74-70143

Hazard Avoidance and Elimination (Wake Vortex)
501-38-13 W74-70150

Fire Retardation
501-38-19 W74-70153

Analysis of Future Civil Air Transportation Systems and Concepts
791-93-03 W74-70156

Analysis of Future Military Aviation Systems and Concepts
791-93-04 W74-70157

Short Haul Transportation Systems Analysis
791-93-05 W74-70158

High Transonic Speed Transport (HiTST) System Study
791-93-06 W74-70159

Study and Analysis of Future National Needs and Potential Aerospace Contributions to Meet Those Needs
791-93-07 W74-70160

Analysis Support for Aeronautical Program Planning
791-93-09 W74-70161

Aeronautical System Analysis (ACSYNT)
791-93-12 W74-70162

Quiet Propulsive-lift Transport Technology-Systems Studies
791-93-14 W74-70164

Study of Potential Utility of RPV's (Remotely Piloted Vehicles) for Civil Applications
791-93-18 W74-70166

VTOL Vehicle Studies
791-94-02 W74-70170

Fuel Tank Sealants
743-31-01 W74-70175

AST Propulsion Noise
743-34-11 W74-70187

AST - Stratospheric Emission Impact
743-34-22 W74-70192

Stability and Control Prediction of Flexible Aircraft
743-36-01 W74-70196

AST-Handling Qualities Criteria for ACT-Configured Advanced Supersonic Aircraft
743-36-11 W74-70200

AST Control System Mechanization Techniques
743-36-12 W74-70201

Advanced Supersonic Technology - Optimum Design/CCV
743-65-11 W74-70205

AST Aerodynamics and Performance (Theory)
743-65-21 W74-70208

Sonic Boom
743-65-31 W74-70209

C-8A Augmentor Wing Proof-of-Concept Flight Program
766-71-01 W74-70212

Flight Experiment Program - Augmentor Wing Jet STOL Research Aircraft
766-71-02 W74-70213

YF-12-Disciplinary Research
766-72-02 W74-70216

F-111 Tact Research Aircraft
766-76-02 W74-70222

V/STOL Tilt Rotor Research Aircraft Program
744-78-01 W74-70225

Noise Reduction Flight Procedures Experiments
768-80-01 W74-70226

VTOL Operating Systems Experiments
768-82-01 W74-70230

Guidance Navigation and Control for the Sea Control Ship VTOL Aircraft
768-82-03 W74-70232

Technology for Advanced Integrated Avionics for Terminal Area Flight Experiments in STOL Aircraft
768-83-01 W74-70233

Microwave Landing System Validation for STOL Aircraft Applications
768-83-02 W74-70234

STOL Operating Systems Experiments Using MODILS and the Civil/Military Microwave Landing System (MLS)
768-83-03 W74-70235

Investigation of the Use of Strapdown Inertial Sensor Units for the Integration of Flight Control, Guidance and Navigation Functions
768-83-05 W74-70237

Terminal Area Effectiveness - Optimization of Flight Procedures of Short Haul Transport Aircraft
768-83-06 W74-70238

Quiet Propulsive Lift Technology
769-89-02 W74-70241

Surface Physics and Chemistry
502-01-01 W74-70242

Physics and Chemistry of Solids
502-01-02 W74-70244

Thermal Control
502-21-27 W74-70257

Shuttle External Insulation
502-31-50 W74-70268

Space Vehicle Dynamics
502-22-11 W74-70283

Space Shuttle Dynamics and Aeroelasticity
502-32-02 W74-70287

Gas Dynamics Research
502-07-01 W74-70330

Advanced Earth-Orbital Transportation Technology
502-27-02 W74-70333

Planetary Entry Technology
502-27-01 W74-70335

Space Shuttle: Configurations and Aerothermodynamics
502-37-01 W74-70339

Space Shuttle Thermal Protection Systems
502-37-02 W74-70342

Precise, All Sky Pointing, Attitude Reference System for Shuttle Ejectable Payloads
502-23-47 W74-70365

Nuclear Flight Research and Analysis
502-19-31 W74-70384

Quantum Electronics
502-10-01 W74-70386

Space Exploration - Mission and Systems Analysis
790-93-41 W74-70394

Space Utilization - Mission and Systems Analysis
790-93-45 W74-70397

Synthesis Study of Spacecraft Systems for low Cost Planetary Spacecraft
757-54-71 W74-70427

Power Conversion of Coherent Light
759-11-21 W74-70436

Air Pollution Reduction
770-18-02 W74-70442

Numerical Model and Simulation of Coupled Earth Energy and Pollution Transport Cycles
175-21-11 W74-70449

Aircraft Support of the Meteorology Program
175-91-11 W74-70468

Laboratory Investigation of Minor Atmospheric Constituents
176-11-11 W74-70472

Remote Sensing of Eutrophication and Other Lake Processes
176-53-11 W74-70479

Global Study of Stratospheric Constituents
176-61-11 W74-70483

Research and Technique Development for Optimum Data Flow
177-11-11 W74-70486

Remote Sensing Data Management, Interpretation Techniques for Earth Resources Surveys
177-32-11 W74-70497

Remote Sensing Sensor Technology for Earth Resources Surveys
177-43-11 W74-70505

F

G

Earth Observations Laboratory, Field Experiments, and Calibration of Radiation Sensors
175-91-42 W74-70470
Technological and Resource Analysis of Meteorological Program Elements
175-91-43 W74-70471
Visible and IR Sensor Subsystems
177-22-41 W74-70488
Sensor Calibration, Test and Simulation
177-26-41 W74-70494
Advanced Image Processing Techniques
177-31-41 W74-70495
Information Extraction Technique Development
177-42-41 W74-70501
Generation of Integrated Thematic Data Base and Demonstration of its Use in Regional Environment/Land Use Management
177-52-41 W74-70520
Investigations for the Hydrological Cycle and Large Hydrological Systems
177-54-41 W74-70536
Remote Sensing of Oceanographic Color and Temperature and Ice Cover of Navigable Waters
177-55-41 W74-70543
Analysis of Advanced Propulsion System Requirements
180-06-50 W74-70555
Isogrid Cylinder Test Program - Combined Loads Including Internal Pressure
180-11-06 W74-70559
Absolute Pressure, Atomic Oxygen, and Energetic Beam Calibration for Mass Spectrometer
185-47-51 W74-70571
Experiment Development for Neutral Gas Composition Measurement in Planetary Atmospheres
185-47-52 W74-70572
Development of Ion Mass Spectrometer for Planetary Atmospheric Experiment
185-47-53 W74-70573
Experiment Development for the Determination of Venus Cloud Particle Composition
185-47-54 W74-70574
Spectroscopy and Photochemistry of Planetary and Cometary Molecules
185-47-55 W74-70575
Negative Ions in Planetary Atmospheres
185-47-56 W74-70576
Cometary Science Study and Research
186-68-64 W74-70598
Magnetodynamics-Nonthermal Plasmas
188-36-55 W74-70601
Magnetospheric Physics - Particles and Particle/Photon Interactions
188-36-56 W74-70603
Shuttle Applications of Ionospheric Plasma Experiments
188-36-64 W74-70606
Development of Experiments and Hardware for Solar Physics Research
188-38-51 W74-70608
Ground Based Observations of the Sun
188-38-52 W74-70610
Experiment Development - Laboratory and Theoretical Solar Physics
188-38-53 W74-70612
Development of Shuttle Payloads for the Study of Solar Flares and Flare Related Phenomena
188-38-64 W74-70616
UV and Optical Astronomy
188-41-51 W74-70619
Ground-Based Radio Astronomy
188-41-52 W74-70622
X-Ray Astronomy
188-41-59 W74-70630
Astronomy Sortie Instruments
188-41-64 W74-70634
X-Ray Spectroscopy for Shuttle
188-41-64 W74-70635
Comets and Interstellar Matter
188-45-51 W74-70639
Cosmic Dust Research
188-45-53 W74-70645
Particle Astrophysics
188-46-56 W74-70647
Gamma Ray Astronomy
188-46-57 W74-70650
Shuttle Definition Studies for High Endrgy Astrophysics
188-46-64 W74-70652
Basic Theoretical Research
188-48-52 W74-70654
Advanced Technological Development, General: On-Board Processing Electronics; Solid State Nuclear Detectors
188-78-51 W74-70656
Design, Analysis, and Evaluation of the Large Space Telescope Optical Instrument System
188-78-56 W74-70658
Origin and Structure of the Planets and the Moon
195-42-63 W74-70688
Ground-Based Infrared Astronomy
196-41-50 W74-70696
Radio and Radar Planetary Studies
196-41-51 W74-70697
Mission Support Computing Systems and Techniques
310-10-22 W74-70709
Tracking Data and Trajectory Analysis
310-10-26 W74-70710
Frequency Standard Sources
310-10-42 W74-70711
Tracking and Data Relay Satellite Technology Development
310-20-20 W74-70716
Investigation of Equatorial Ionospheric Propagation
310-20-23 W74-70717
Network Timing and Synchronization Technology
310-20-27 W74-70718
A Ground Antenna for Wideband Data Transmission Systems
310-20-31 W74-70719
High Reliability Control Systems for Antennas
310-20-32 W74-70720
Unified Spacecraft RF Subsystem Development
310-20-46 W74-70721
Advanced Network Planning
310-30-21 W74-70725
30 Mbps Station Data Handling Equipment
310-30-24 W74-70726
Network Utilization and Shuttle Studies 1979-1990
310-30-35 W74-70727
Automatic Computer Program Documentation
310-40-25 W74-70730
Automatic Data Handling
310-40-36 W74-70731
Computational Support
310-40-38 W74-70732
Image Processing Facility Performance Evaluation and Improvement
310-40-39 W74-70733

J

Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
Basic Noise Research
501-04-01 W74-70046
Basic Pollution Research
501-04-02 W74-70050
Computational Aerodynamics
501-06-01 W74-70075
Airframe Noise
501-06-13 W74-70091
Hazard Avoidance
501-38-13 W74-70148
Properties of Materials for Electronic Applications
502-01-03 W74-70246
Non-Metallic Superconductors
502-01-05 W74-70249
Viscoelastic Properties of Polymers
502-01-08 W74-70252
Advanced Concepts for Spacecraft Antenna Structures
502-22-05 W74-70273
Space Vehicle Dynamics
502-22-11 W74-70280
Spacecraft Liquid Propulsion Research
502-04-20 W74-70290
New Horizons in Propulsion
502-04-38 W74-70295
Solid Propellant Research
502-04-45 W74-70297
Long Life Advanced Propulsion Systems
502-24-26 W74-70299
Advanced Solid Propulsion and Pyrotechnic Concepts
502-24-46 W74-70303
SEP Systems Integration
502-24-10 W74-70307
Solar-Electric Propulsion Thrust Subsystem
502-24-11 W74-70308
Pulsed Plasma Thruster System Technology Development
502-24-18 W74-70310
Planetary Solar Power Research
502-05-54 W74-70314
Electrochemical Energy Storage Research
502-05-55 W74-70315
Planetary Solar Power Technology
502-25-56 W74-70318
Deep Space Batteries
502-25-57 W74-70319
Long-Life, High-Performance Power Processing for Planetary Applications
502-25-74 W74-70325
Planetary Entry Technology
502-27-01 W74-70337
Artificial Intelligence for Integrated Robot Systems
502-03-32 W74-70347
Extended Life Attitude Control System (ELACS) for Unmanned Planetary Vehicles
502-23-46 W74-70356
Microwave Techniques and Components
502-23-12 W74-70362
Predictable Long-Life Component Technology
502-23-53 W74-70368
Advanced Digital Data Systems for Deep Space
502-33-31 W74-70379
Guidance and Navigation for Unmanned Planetary Vehicles
502-33-41 W74-70380
Microwave Systems Technology
502-33-92 W74-70381
Advanced Imaging Systems Technology
502-33-94 W74-70382
Quantum Electronics
502-10-01 W74-70387
Advanced Concepts and Future Planning
790-93-09 W74-70392
Mission and Vehicle Analysis
790-93-44 W74-70396
Standardization of Elements of Electrical Power Subsystems for Unmanned Spacecraft
757-54-41 W74-70410
Low Cost Control System Sensor Standardization
757-54-42 W74-70411
Low Cost, Cold Gas Attitude Control Propulsion Standardization
757-54-43 W74-70412
Low Cost N2H4 Attitude Control Propulsion Standardization
757-54-44 W74-70413
Low Cost Standardized Planetary Spacecraft Transponders
757-54-46 W74-70414
Tape Recorder for Planetary Standards
757-54-47 W74-70415
Flight Operations Cost Improvements - Long Term Missions
757-54-49 W74-70416
Standardization of Lunar and Planetary Subsystems
757-54-51 W74-70417
Standardized G and C Subsystem Integration Equipment
757-54-52 W74-70418
Standard Electronic Equipment Packaging System
757-54-53 W74-70419
Standardized Thermal Management for Unmanned Spacecraft
757-54-54 W74-70420
Universal Scanning Devices
757-54-55 W74-70421
Planetary S/C High-Gain Antenna Standardization
757-54-56 W74-70422
Tape Recorder Standards Component Development
757-54-59 W74-70423
Nonrigid Body Dynamics and Control Interaction Simulation Module
757-54-60 W74-70424
Low Cost Standardized Planetary Spacecraft RF Power Supplies
757-54-82 W74-70428
Standardized Pyrotechnics for Planetary and Applications Missions
757-54-83 W74-70429
Solid Rocket Standardized Handling and Inspections
757-54-84 W74-70430
Standardized Space Imaging System
757-54-86 W74-70431
National Standardization of Lunar and Planetary Precision Trajectory Program
757-54-87 W74-70432
Laser Energy Conversion Research
759-11-24 W74-70437
Laser Device Research
759-11-34 W74-70438
Civil Applications - Public Safety/Service and Environmental Engineering
770-18-08 W74-70444
Application of Satellite Data to Modeling, Predicting, and Monitoring the Earth's Atmosphere
175-21-51 W74-70455
Atmospheric Pollution Sensing: Heterodyne Spectroscopy
176-31-51 W74-70477
Measurement of Pollutants in an Urban Environment
176-91-51 W74-70485
Data Management and Storage
177-25-51 W74-70493
Earth Resources Geology/Geomorphology
177-31-51 W74-70496
Microwave Geothermal Exploration
177-44-51 W74-70507
Oceanographic Studies (Radar)
177-55-51 W74-70544
Microwave Radiometric Measurement of Ice Thickness
177-55-52 W74-70545
Electric Propulsion Reliability
180-06-51 W74-70556
Engineering Instrumentation
180-24-51 W74-70565
Liquid Propulsion Technology
180-31-52 W74-70566
Solid Propulsion Technology
180-32-52 W74-70569
Atmospheric Experiment Development
185-47-71 W74-70581
Theoretical Studies - Planetary Atmospheres
185-47-72 W74-70582
Planetology Studies - Imaging
185-50-71 W74-70591
Imaging System Technology for Planetary Missions
186-68-52 W74-70593
G and C Technology for Mars Roving Vehicles
186-68-55 W74-70594
Propellant Compatibility with Materials for Long Duration Missions
186-68-62 W74-70596
Magnetospheric Physics: Magnetodynamics
188-36-55 W74-70602
Radio Astronomy
188-41-52 W74-70621

L

M

N

W

Page Intentionally Left Blank

RTOP Summary

FISCAL YEAR 1974

TYPICAL RTOP NUMBER INDEX LISTING

This section may be used to identify the RTOP accession number of reports covered in this journal. Thus this section of this index may be used to locate the bibliographic citations and technical summaries in the Summary Section. The RTOP numbers are listed in ascending number order.

☆U.S. GOVERNMENT PRINTING OFFICE: 739-154/63

"The aeronautical and space activities of the United States shall be conducted so as to contribute . . . to the expansion of human knowledge of phenomena in the atmosphere and space. The Administration shall provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof."

—NATIONAL AERONAUTICS AND SPACE ACT OF 1958

NASA SCIENTIFIC AND TECHNICAL PUBLICATIONS

TECHNICAL REPORTS: Scientific and technical information considered important, complete, and a lasting contribution to existing knowledge.

TECHNICAL NOTES: Information less broad in scope but nevertheless of importance as a contribution to existing knowledge.

TECHNICAL MEMORANDUMS: Information receiving limited distribution because of preliminary data, security classification, or other reasons. Also includes conference proceedings with either limited or unlimited distribution.

CONTRACTOR REPORTS: Scientific and technical information generated under a NASA contract or grant and considered an important contribution to existing knowledge.

TECHNICAL TRANSLATIONS: Information published in a foreign language considered to merit NASA distribution in English.

SPECIAL PUBLICATIONS: Information derived from or of value to NASA activities. Publications include final reports of major projects, monographs, data compilations, handbooks, sourcebooks, and special bibliographies.

TECHNOLOGY UTILIZATION PUBLICATIONS: Information on technology used by NASA that may be of particular interest in commercial and other non-aerospace applications. Publications include Tech Briefs, Technology Utilization Reports and Technology Surveys.

Details on the availability of these publications may be obtained from:

SCIENTIFIC AND TECHNICAL INFORMATION OFFICE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Washington, D.C. 20546